Systemic Vulnerabilities

Allen D. Householder

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DM-0001744

Systemic Vulnerabilities

Allen D. Householder

Systemic Vulnerabilities

An Allegorical Tale of Steampunk Vulnerability to Aero-Physical Threats

Allen D. Householder

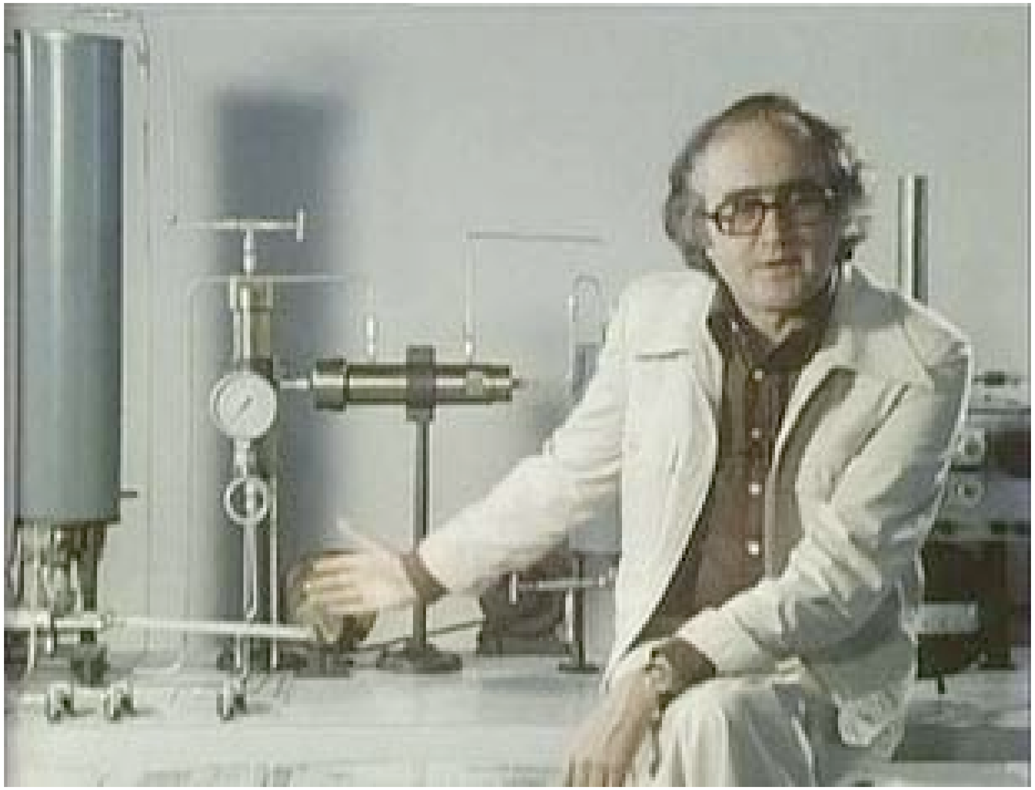
http://ambassadormann.deviantart.com/art/Steampunk-Goggles-number-2-127699287

Prologue: 1979

“Why should we look to the past in order to prepare for the future? Because there is nowhere else to look.”

James Burke,

Connections



http://upload.wikimedia.org/wikipedia/en/archive/2/2e/20130124220825!James_Burke_%28historian%29.jpg

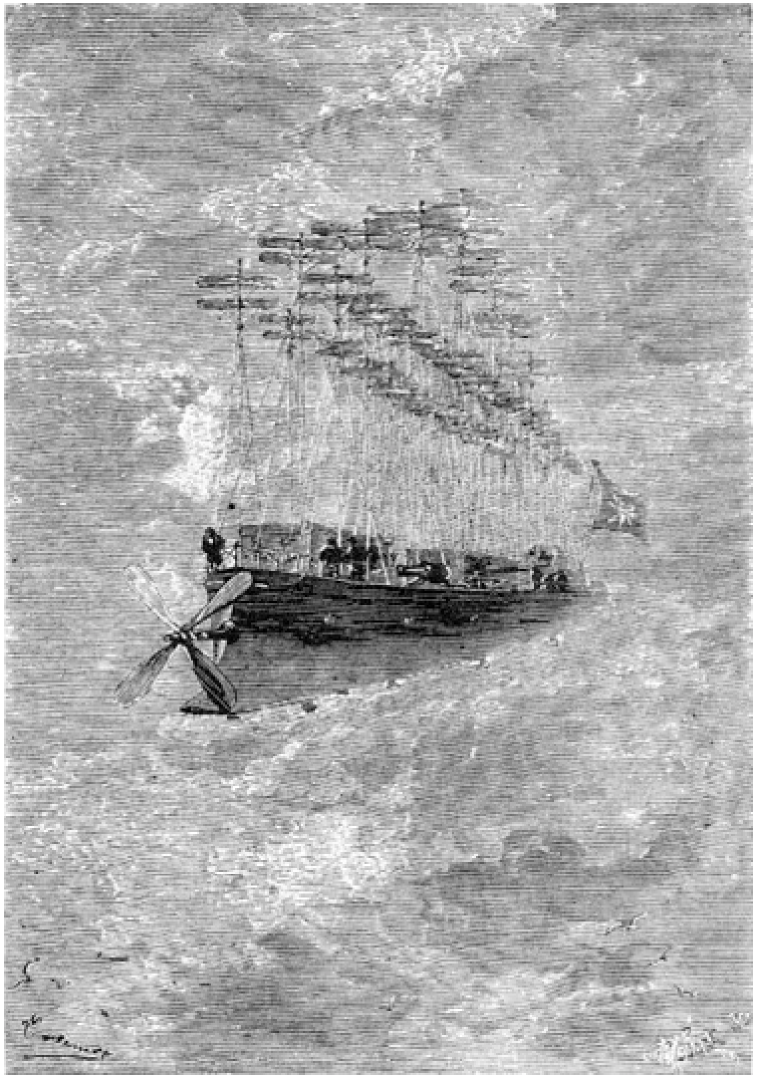
Prologue: 1878

http://en.wikipedia.org/wiki/File:F%C3%A9lix_Nadar_1820-1910_portraits_Jules_Verne_%28restoration%29.jpg

Prologue: 1886

http://en.wikipedia.org/wiki/File:%27Robur_the_Conqueror%27_by_L%C3%A9on_Benett_01.jpg

Prologue: 1886



http://upload.wikimedia.org/wikipedia/commons/3/3d/%27Robur_the_Conqueror%27_by_L%C3%A9on_Benett_14.jpg

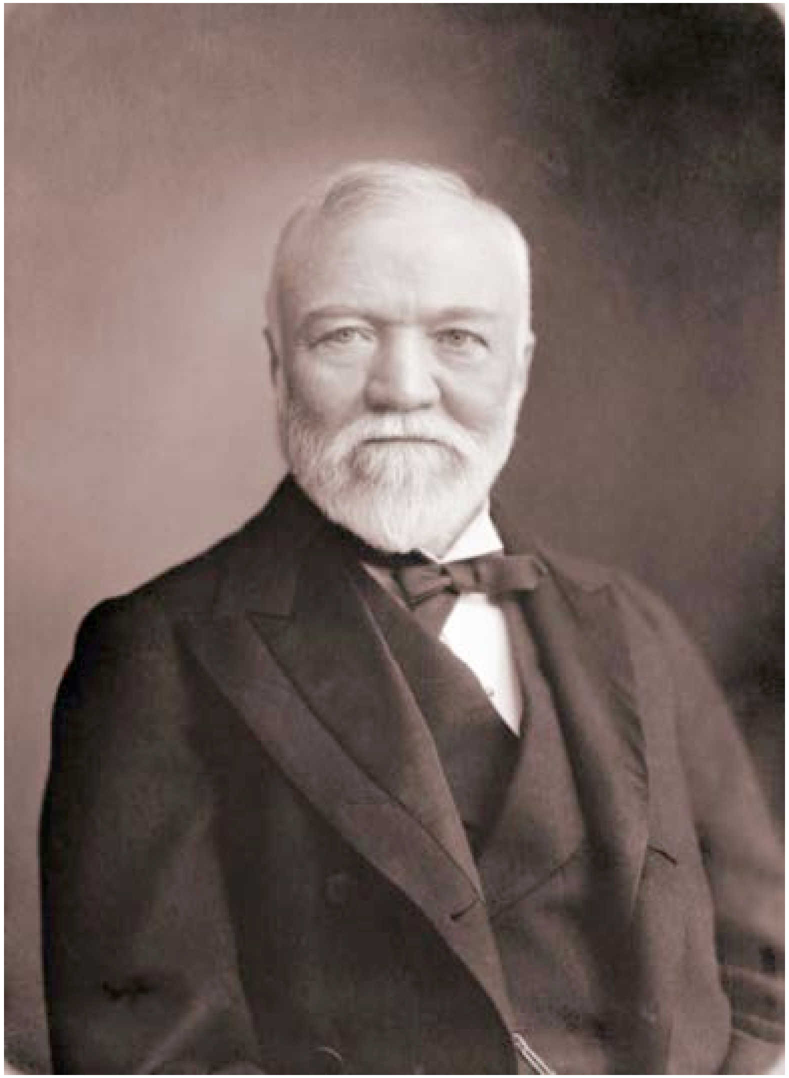
Prologue: 1890

http://en.wikipedia.org/wiki/File:Daniel_Burnham_c1890.jpeg

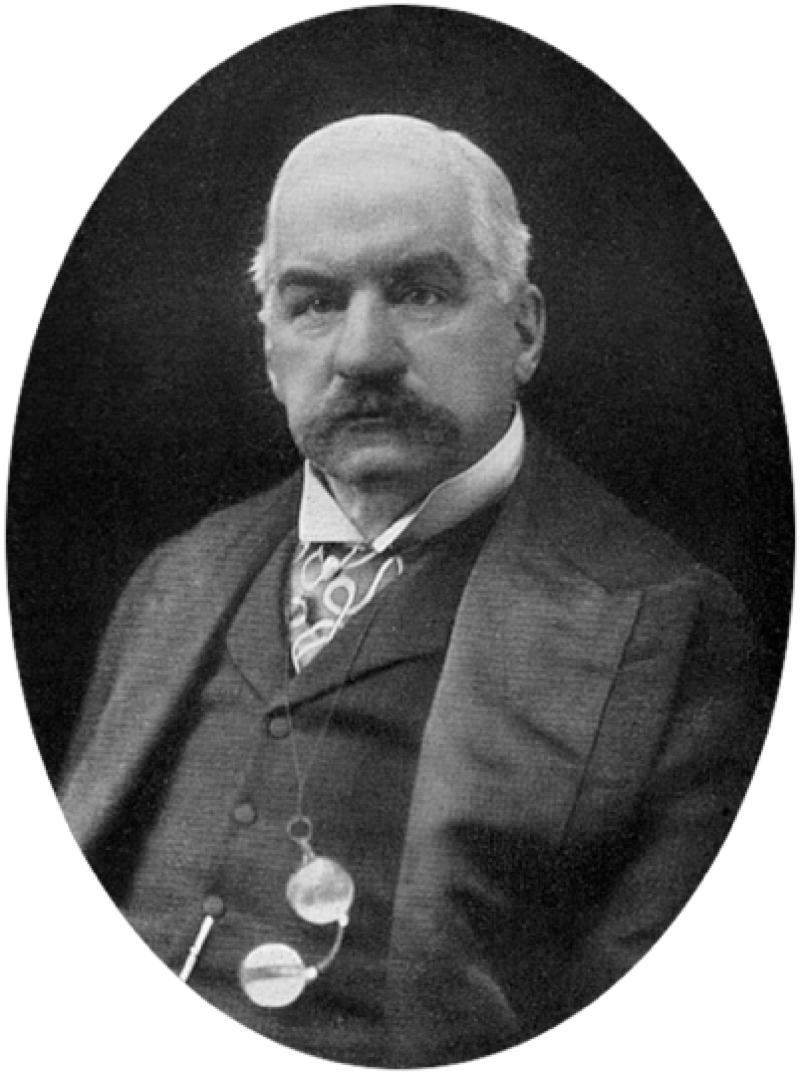
Prologue: 1893

http://www.bc.edu/bc_org/avp/cas/fnart/fa267/1893/1893_02.jpg

Prologue: 1900

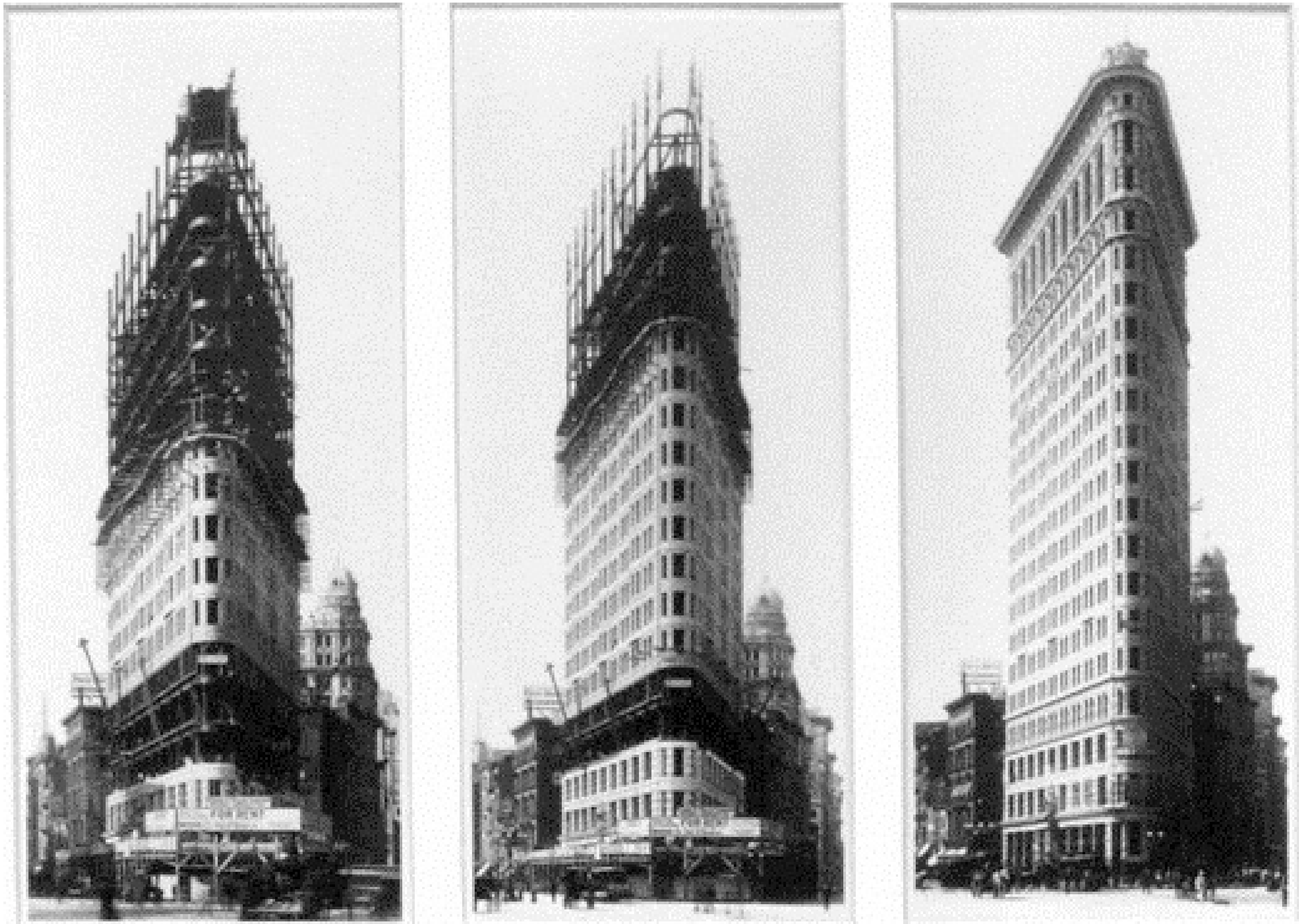


http://explorepahistory.com/displayimage.php?imgId=1-2-A46



http://en.wikipedia.org/wiki/File:JohnPierpontMorgan.png

1901-1902



http://en.wikipedia.org/wiki/File:Flatiron_Building_Construction,_New_York_Times_-_Library_of_Congress,_1901-1902_crop.JPG

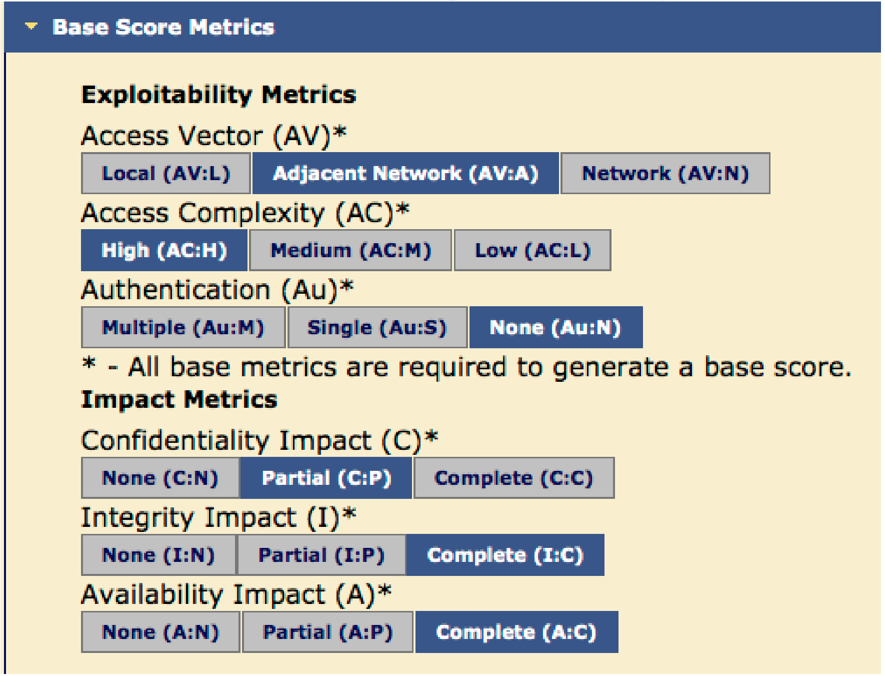
1902

Dropping 40kDay

The Flat Iron Building in New York City is vulnerable to denial of service or complete system destruction due to inadequate defenses against the kinetic and chemical energy of 315,000 lbs of aluminum containing 16,000 gallons of kerosene impacting at 500 mph.

CVSS Base Score: 6.5

(AV:A/AC:H/Au:N/C:P/I:C/A:C)



Base Score Metrics

Exploitability Metrics

Access Vector (AV)*

Local (AV:L) [✓ Adjacent Network (AV:A)] Network (AV:N)

Access Complexity (AC)*

[✓ High (AC:H)] Medium (AC:M) Low (AC:L)

Authentication (Au)*

Multiple (Au:M) Single (Au:S) [✓ None (Au:N)]

* - All base metrics are required to generate a base score.

Impact Metrics

Confidentiality Impact (C)*

None (C:N) [✓ Partial (C:P)] Complete (C:C)

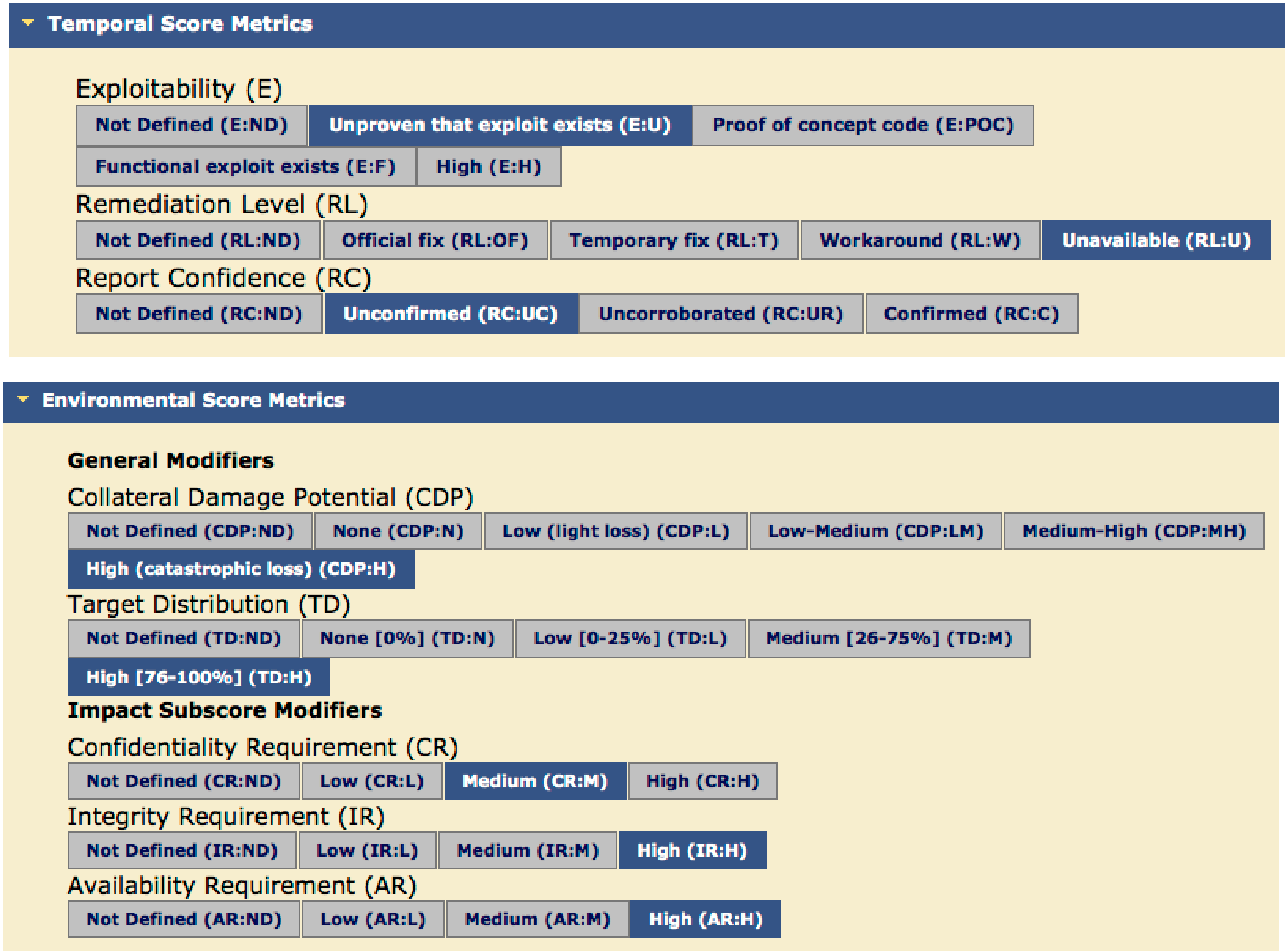
Integrity Impact (I)*

None (I:N) Partial (I:P) [✓ Complete (I:C)]

Availability Impact (A)*

None (A:N) Partial (A:P) [✓ Complete (A:C)]

CVSS v2 1902



Temporal Score Metrics

Exploitability (E)

Not Defined (E:ND) [✓ Unproven that exploit exists (E:U)] Proof of concept code (E:POC) Functional exploit exists (E:F) High (E:H)

Remediation Level (RL)

Not Defined (RL:ND) Official fix (RL:OF) Temporary fix (RL:T) Workaround (RL:W) [✓ Unavailable (RL:U)]

Report Confidence (RC)

Not Defined (RC:ND) [✓ Unconfirmed (RC:UC)] Uncorroborated (RC:UR) Confirmed (RC:C)

Environmental Score Metrics

General Modifiers

Collateral Damage Potential (CDP)

Not Defined (CDP:ND) None (CDP:N) Low (light loss) (CDP:L) Low-Medium (CDP:LM) Medium-High (CDP:MH) [✓ High (catastrophic loss) (CDP:H)]

Target Distribution (TD)

Not Defined (TD:ND) None [0%] (TD:N) Low [0-25%] (TD:L) Medium [26-75%] (TD:M) [✓ High [76-100%] (TD:H)]

Impact Subscore Modifiers

Confidentiality Requirement (CR)

Not Defined (CR:ND) Low (CR:L) [✓ Medium (CR:M)] High (CR:H)

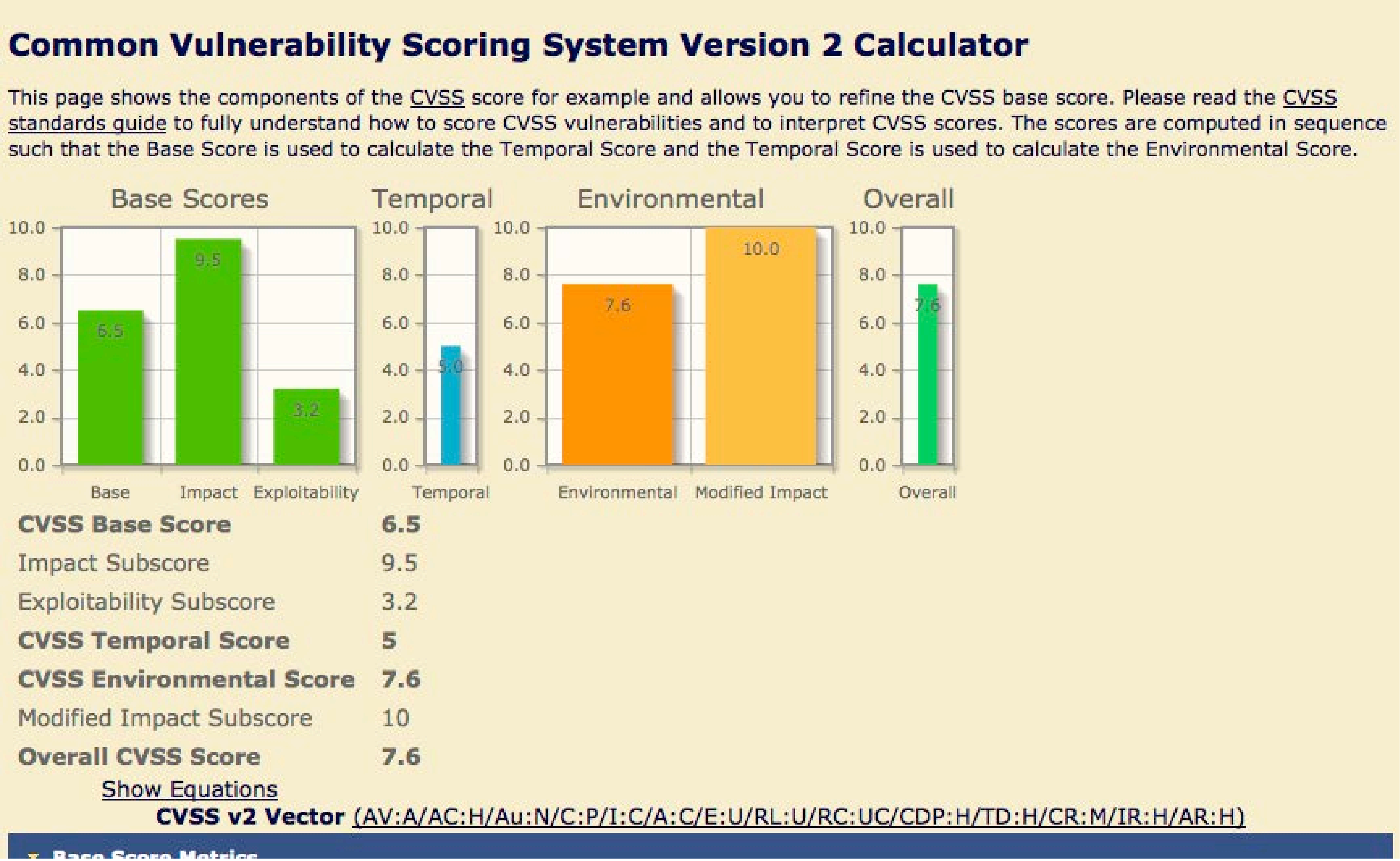
Integrity Requirement (IR)

Not Defined (IR:ND) Low (IR:L) Medium (IR:M) [✓ High (IR:H)]

Availability Requirement (AR)

Not Defined (AR:ND) Low (AR:L) Medium (AR:M) [✓ High (AR:H)]

CVSS v2 1902



Common Vulnerability Scoring System Version 2 Calculator

This page shows the components of the CVSS score for example and allows you to refine the CVSS base score. Please read the CVSS standards guide to fully understand how to score CVSS vulnerabilities and to interpret CVSS scores. The scores are computed in sequence such that the Base Score is used to calculate the Temporal Score and the Temporal Score is used to calculate the Environmental Score.

CVSS Base Score	**6.5**
Impact Subscore	9.5
Exploitability Subscore	3.2
CVSS Temporal Score	**5**
CVSS Environmental Score	**7.6**
Modified Impact Subscore	10
Overall CVSS Score	**7.6**

Show Equations

CVSS v2 Vector (AV:A/AC:H/Au:N/C:P/I:C/A:C/E:U/RL:U/RC:UC/CDP:H/TD:H/CR:M/IR:H/AR:H)

▼ **Base Score Metrics**

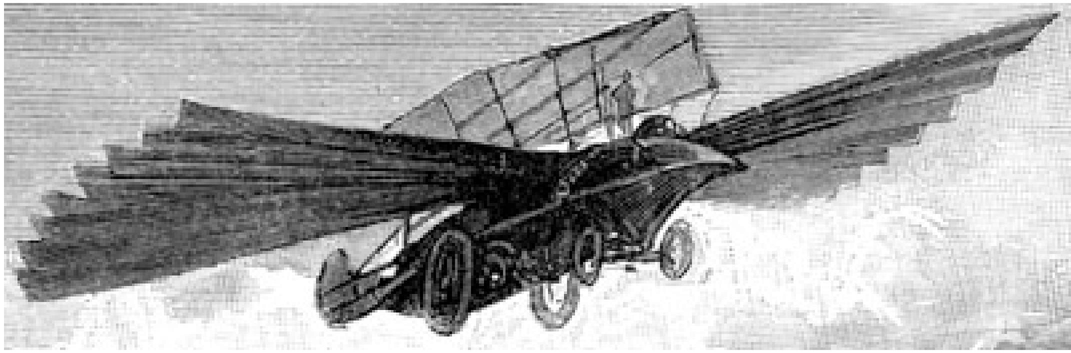
http://nvd.nist.gov/cvss.cfm?calculator&version=2&vector=(AV:A/AC:H/Au:N/C:P/I:C/A:C/E:U/RL:U/RC:UC/CDP:H/TD:H/CR:M/IR:H/AR:H)

1903

http://en.wikipedia.org/wiki/File:First_flight2.jpg

1904

http://en.wikipedia.org/wiki/Master_of_the_World_%28novel%29



http://www.julesverne.ca/images/book/illustratrations/Maitre%20du%20Monde_image%20epouvante%20over%20niagara_detail.jpg

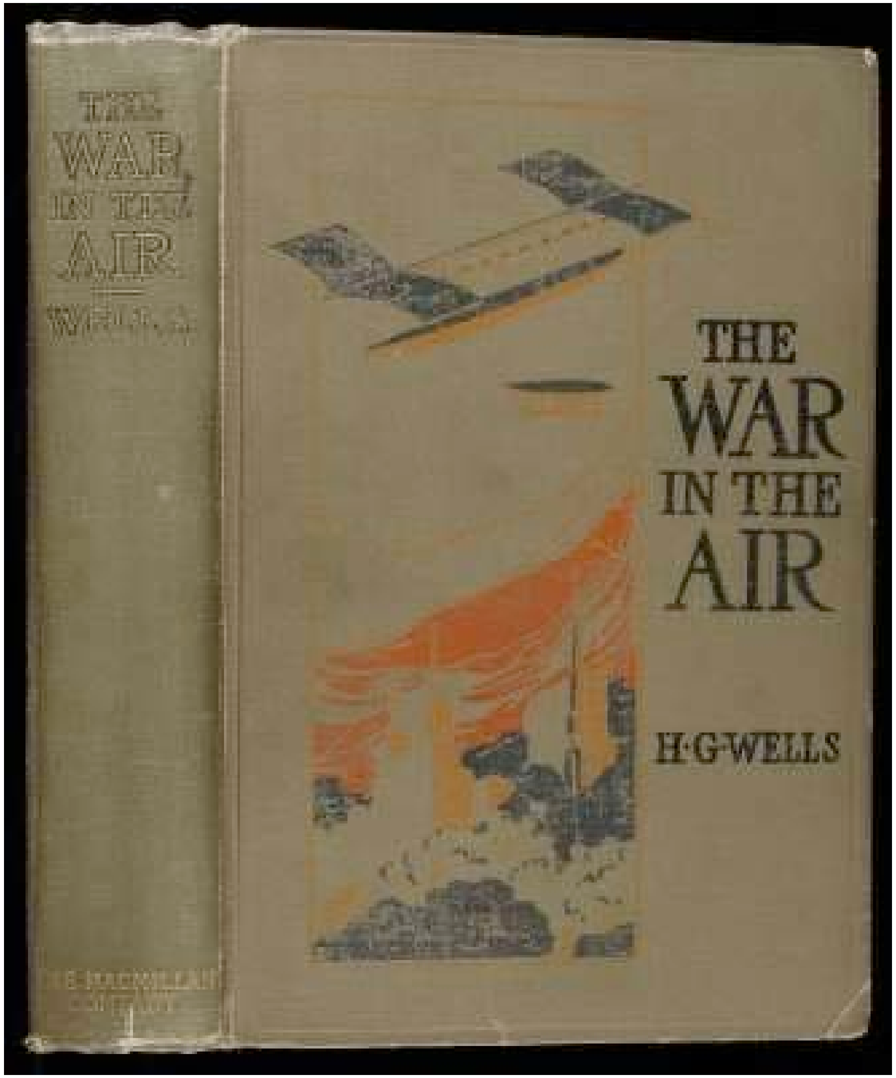
1906

I found myself agape, admiring a sky-scraper, the prow of the Flat-iron Building, to be particular, ploughing up through the traffic of Broadway and Fifth Avenue in the afternoon light.

H.G. Wells, 1906

http://en.wikipedia.org/wiki/File:H_G_Wells_-_Sandgate_-_Project_Gutenberg_eText_13715.png

1908


THE WAR IN THE AIR
WELLS
THE MACMILLAN COMPANY
THE WAR IN THE AIR
H·G·WELLS

1915

Flat Iron Building.
Broadway and Fifth Avenue,
New York City.

http://www.pinterest.com/pin/432275264204090218/

Shortly thereafter

Flat Iron Building,
Broadway and Fifth
Avenue,
New York City.

http://ephemeralnewyork.files.wordpress.com/2009/08/flatironbuildingpostcard.jpg

1918

http://en.wikipedia.org/wiki/File:Hannover_CL_IIIa,_Forest_of_Argonne,_France,_1918_%28restored%29.jpg

1939

http://en.wikipedia.org/wiki/File:B-25G_Mitchell,_AAF_TAC_Center,_Florida_-_040315-F-9999G-005.jpg

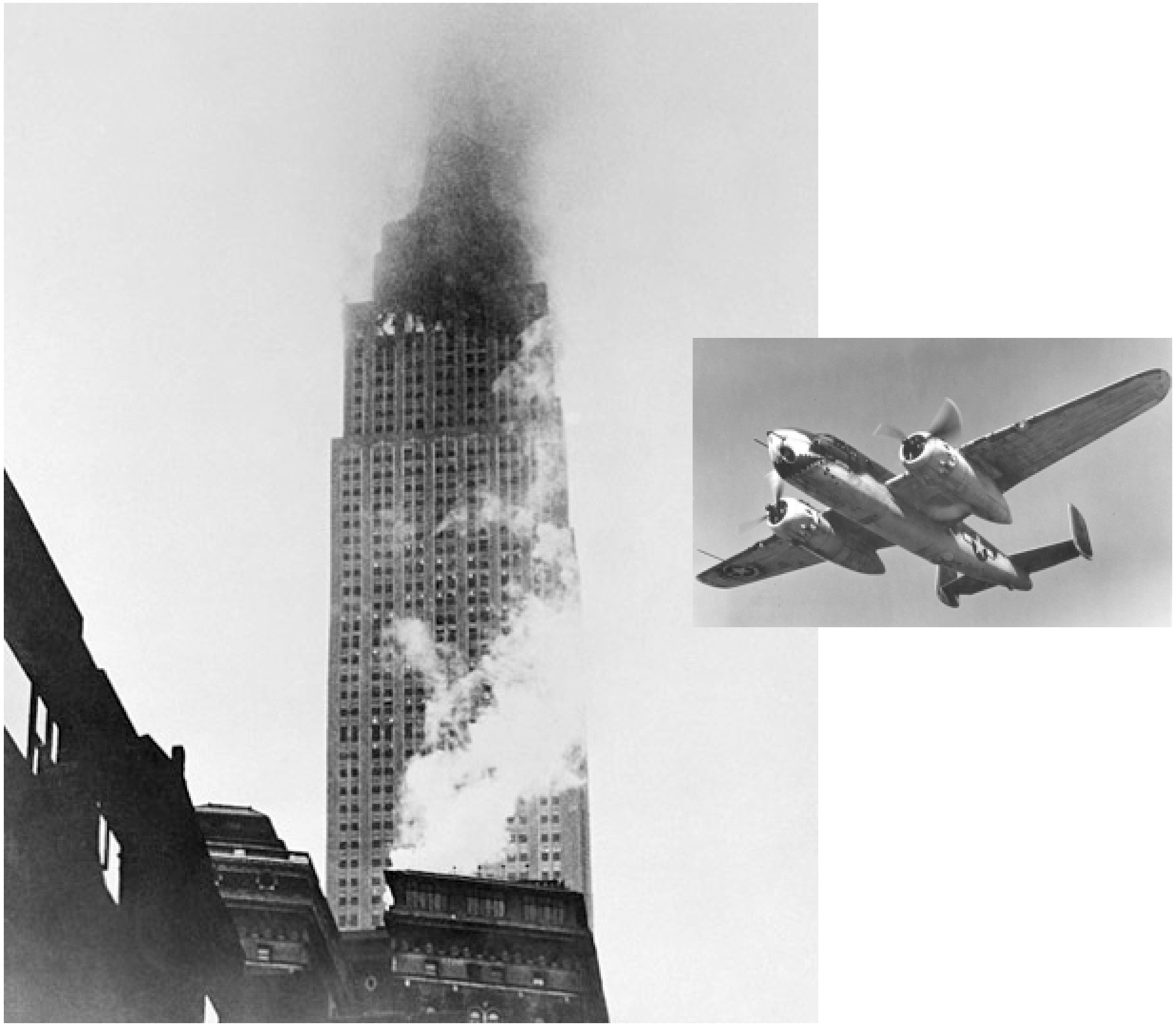
1939

http://www.nationalmuseum.af.mil/shared/media/photodb/photos/060720-F-1234P-001.jpg

1943

http://en.wikipedia.org/wiki/File:Lulu-Belle_af.jpg

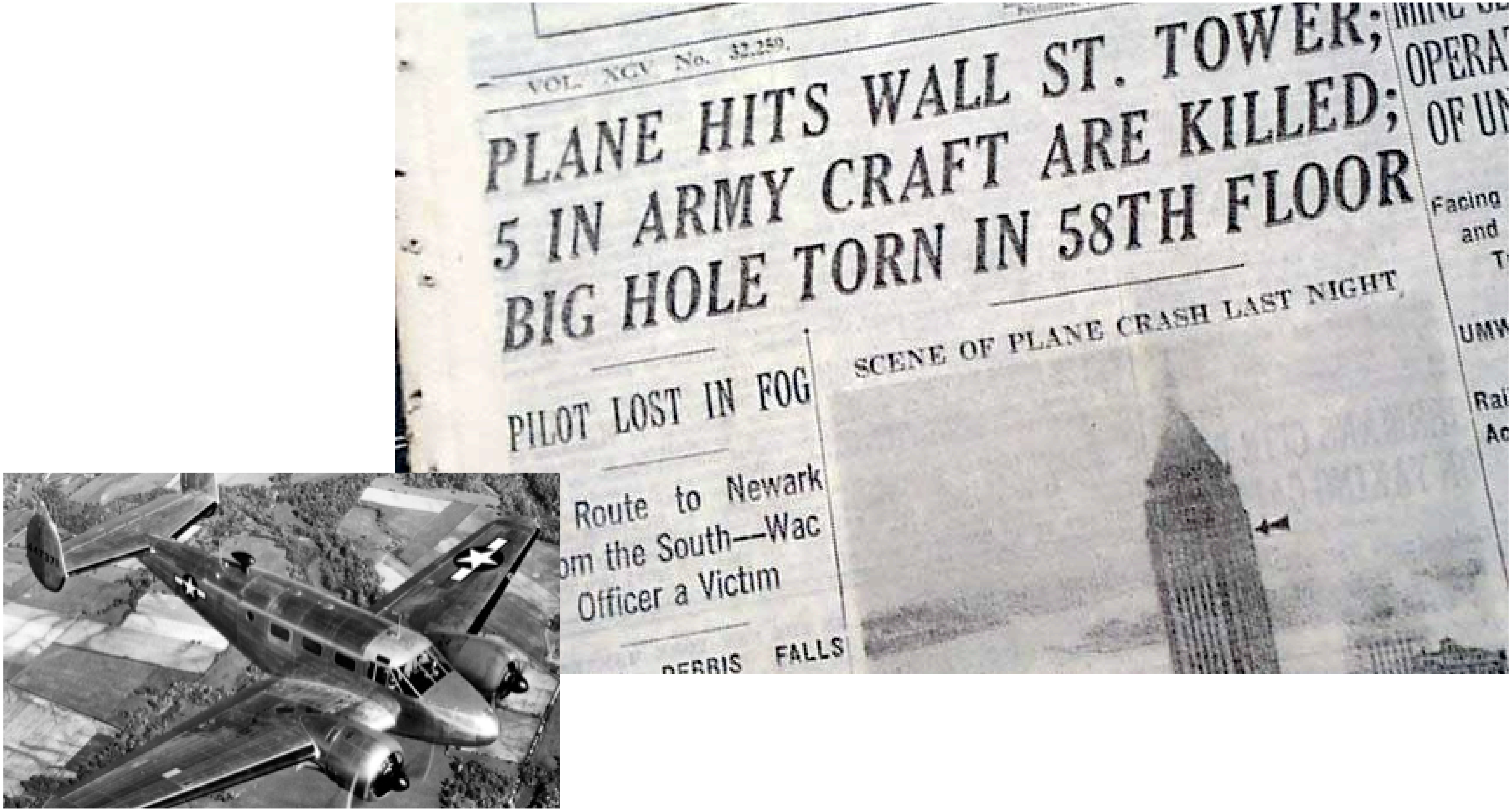
1945



http://en.wikipedia.org/wiki/File:Empirestate540.jpg

The view from here

1946



VOL. XCV No. 32,259.

PLANE HITS WALL ST. TOWER; 5 IN ARMY CRAFT ARE KILLED; BIG HOLE TORN IN 58TH FLOOR

PILOT LOST IN FOG

Route to Newark
om the South—Wac
Officer a Victim

DEBRIS FALLS

SCENE OF PLANE CRASH LAST NIGHT

OPERA
OF UN

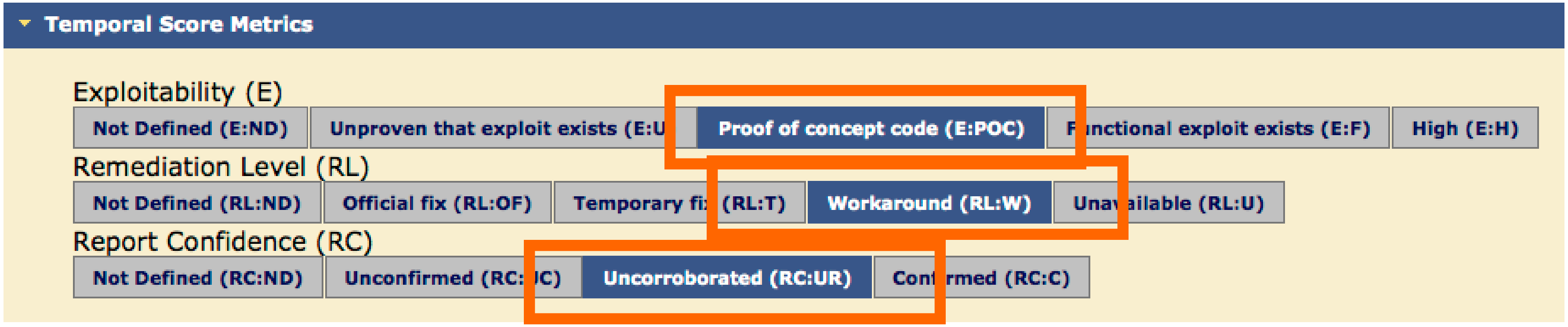
Facing
and

UMW

Ra
Ac

http://images.rarenewspapers.com/ebayimgs/5.5.2010/image028.jpg

CVSS v2 1946



▾ Temporal Score Metrics

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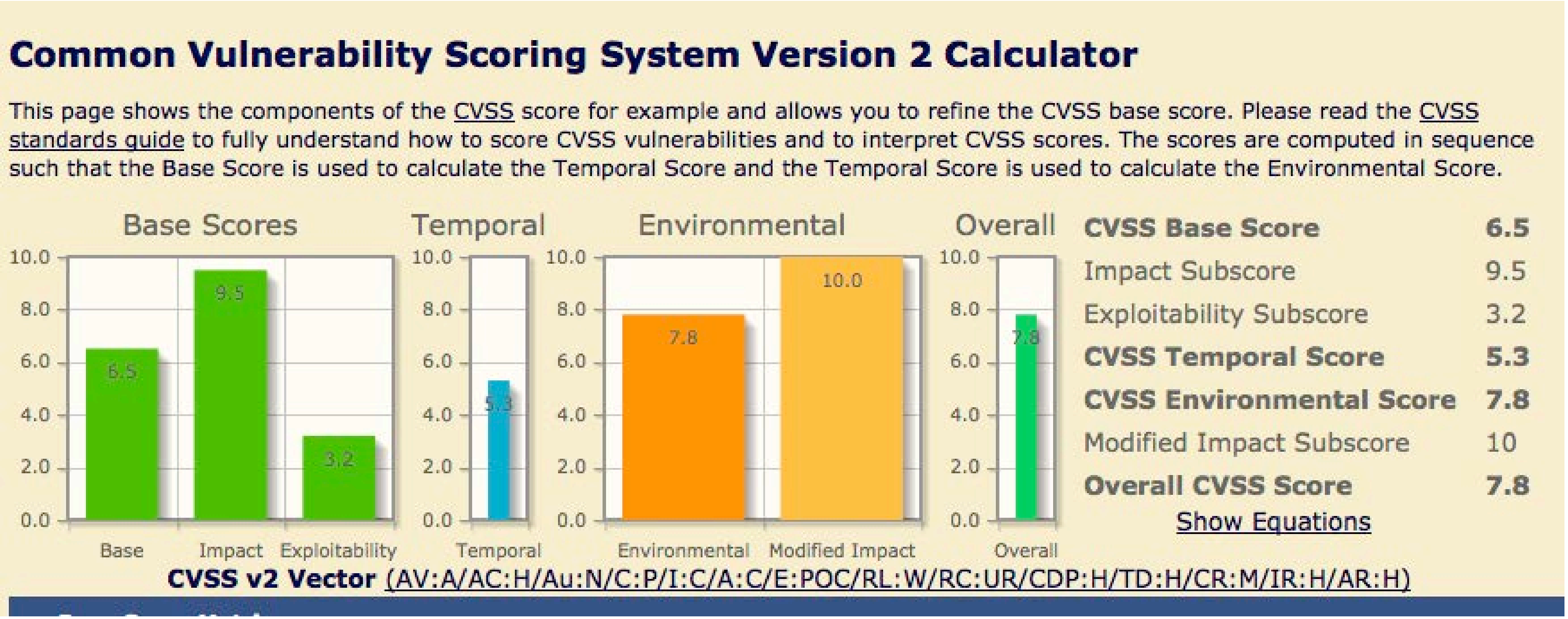

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Impact Subscore	9.5
Exploitability Subscore	3.2
CVSS Temporal Score	**5.3**
CVSS Environmental Score	**7.8**
Modified Impact Subscore	10
Overall CVSS Score	**7.8**

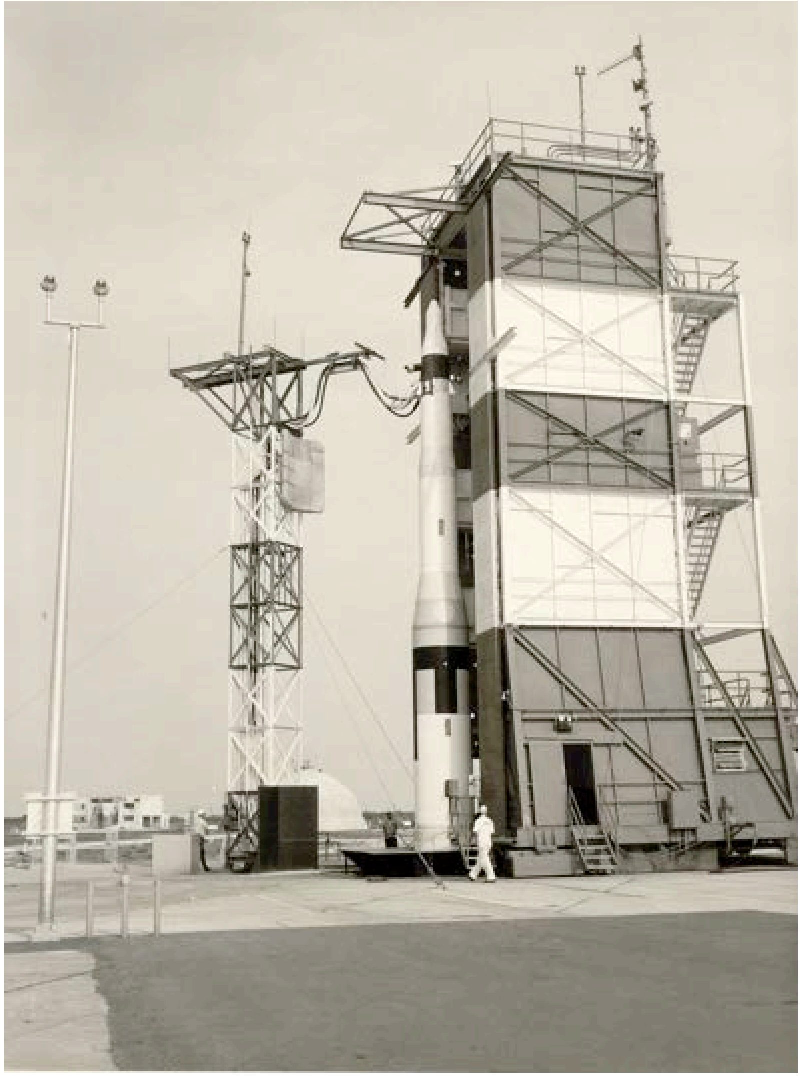
Show Equations

CVSS v2 Vector (AV:A/AC:H/Au:N/C:P/I:C/A:C/E:POC/RL:W/RC:UR/CDP:H/TD:H/CR:M/IR:H/AR:H)

Disclaiming Responsibility for the Fire
(Verses 1-4 go here)

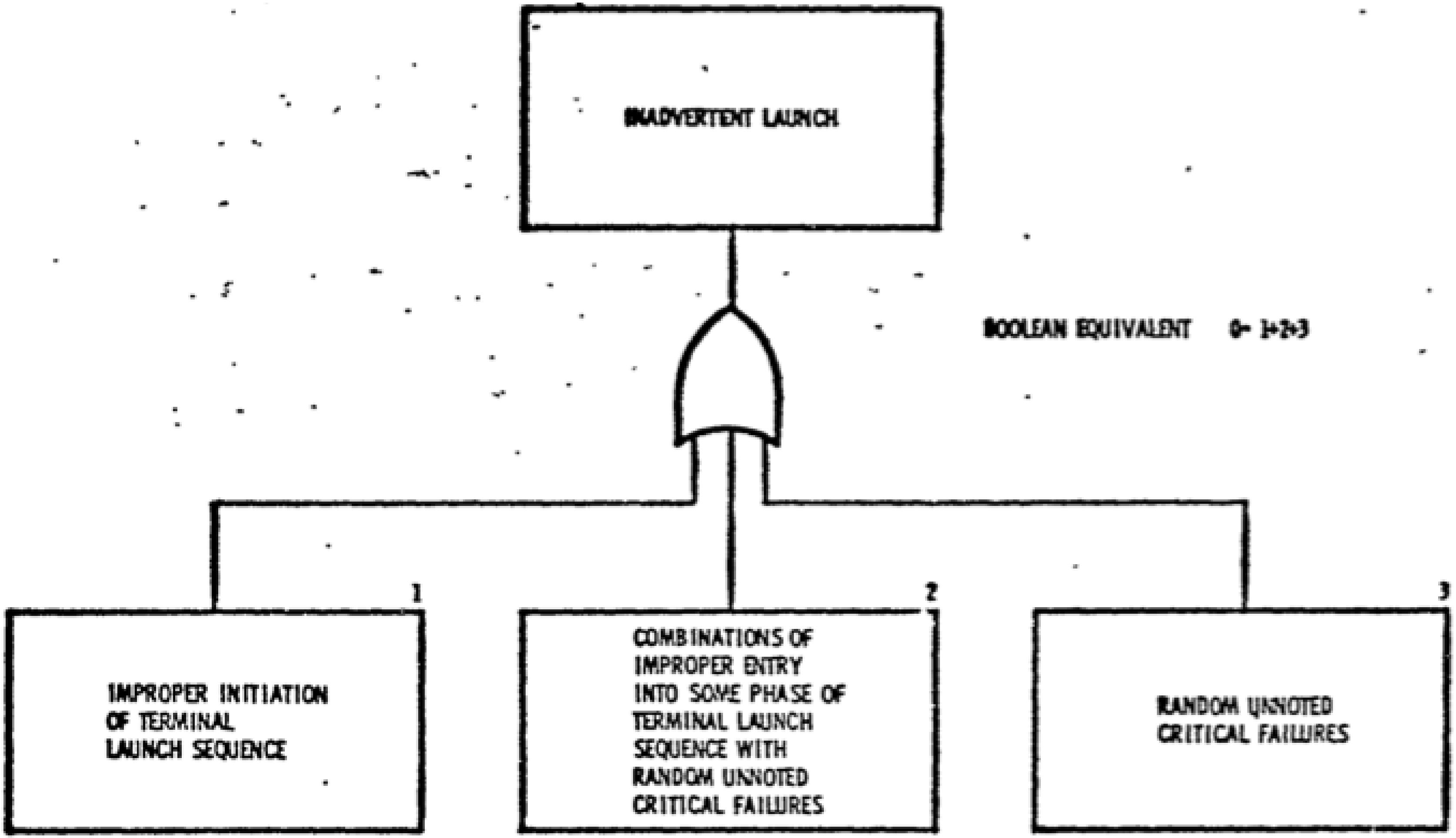
http://eil.com/shop/moreinfo.asp?catalogid=76681

1962



http://en.wikipedia.org/wiki/LGM-30_Minuteman#mediaviewer/File:Minuteman_I.jpg

1963



INADVERTENT LAUNCH

BOOLEAN EQUIVALENT 0= 1+2+3

1

IMPROPER INITIATION OF TERMINAL LAUNCH SEQUENCE

2

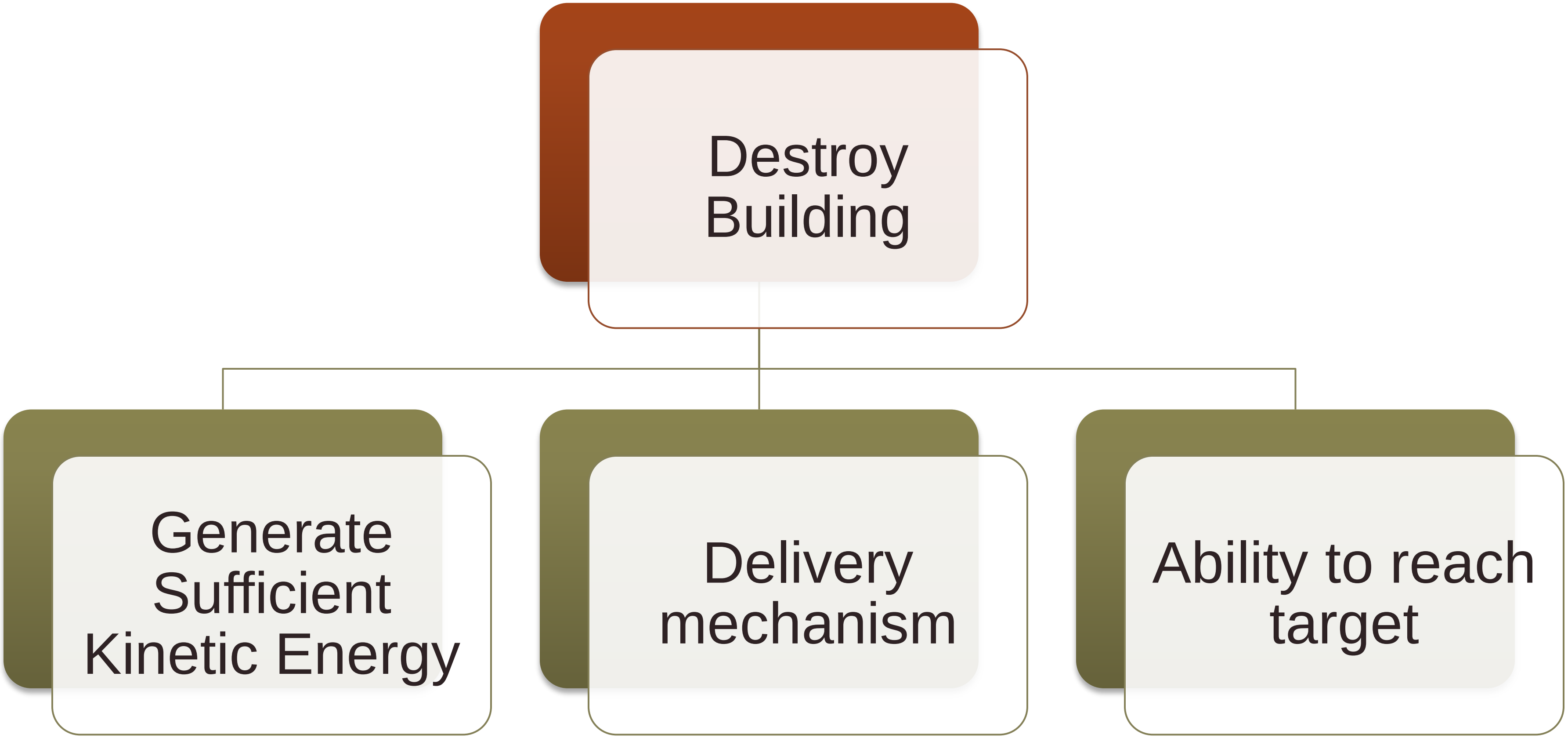
COMBINATIONS OF IMPROPER ENTRY INTO SOME PHASE OF TERMINAL LAUNCH SEQUENCE WITH RANDOM UNNOTED CRITICAL FAILURES

3

RANDOM UNNOTED CRITICAL FAILURES

http://www.dtic.mil/get-tr-doc/pdf?AD=AD0299561

Basic attack tree



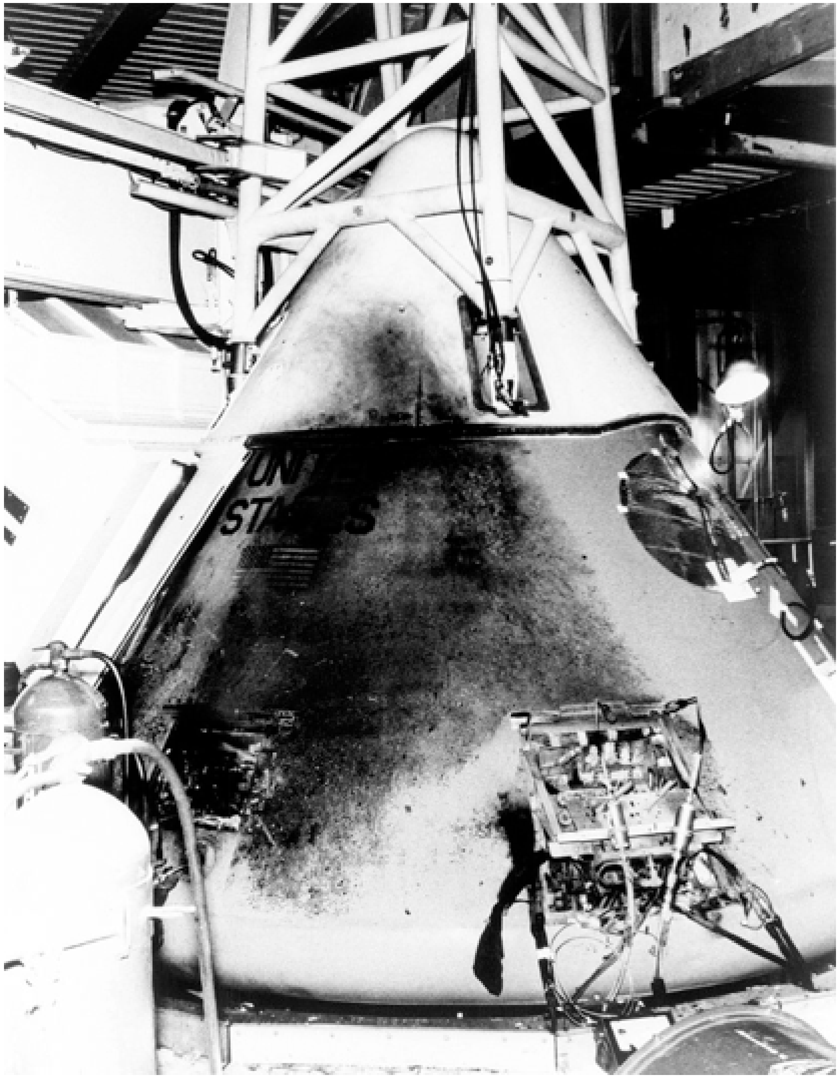
Destroy Building

Generate Sufficient Kinetic Energy

Delivery mechanism

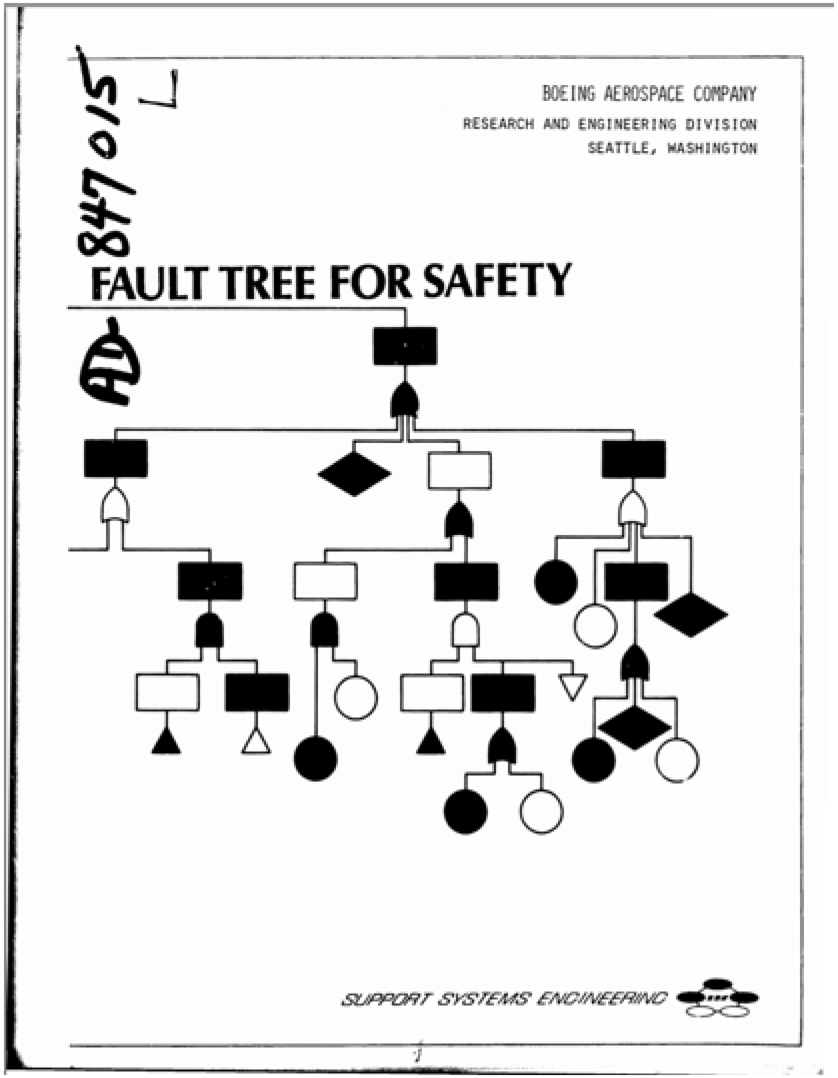
Ability to reach target

1967



http://en.wikipedia.org/wiki/Apollo_1#mediaviewer/File:Apollo_1%27s_Command_Module_-_GPN-2003-00057.jpg

1968



AD 847015 L

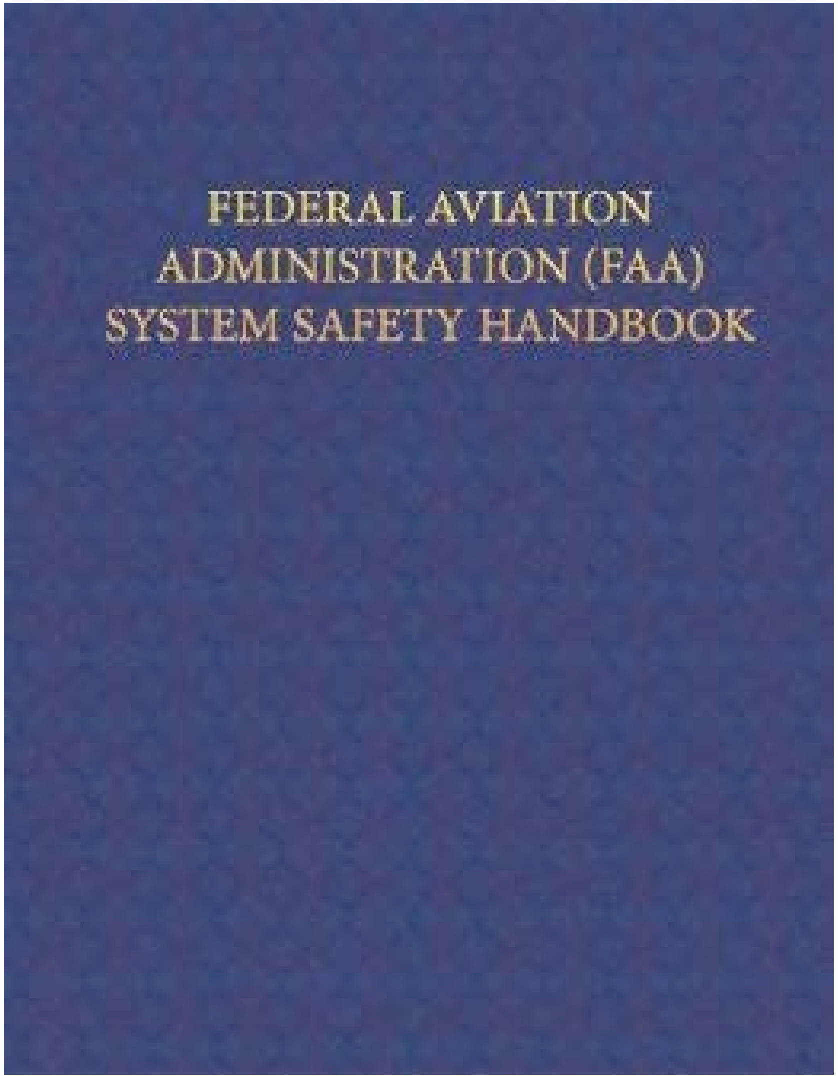
BOEING AEROSPACE COMPANY
RESEARCH AND ENGINEERING DIVISION
SEATTLE, WASHINGTON

FAULT TREE FOR SAFETY

SUPPORT SYSTEMS ENGINEERING

http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=AD0847015

1970



FEDERAL AVIATION
ADMINISTRATION (FAA)
SYSTEM SAFETY HANDBOOK

http://www.barnesandnoble.com/w/federal-aviation-administration-system-safety-handbook-federal-aviation-administration/1118719983

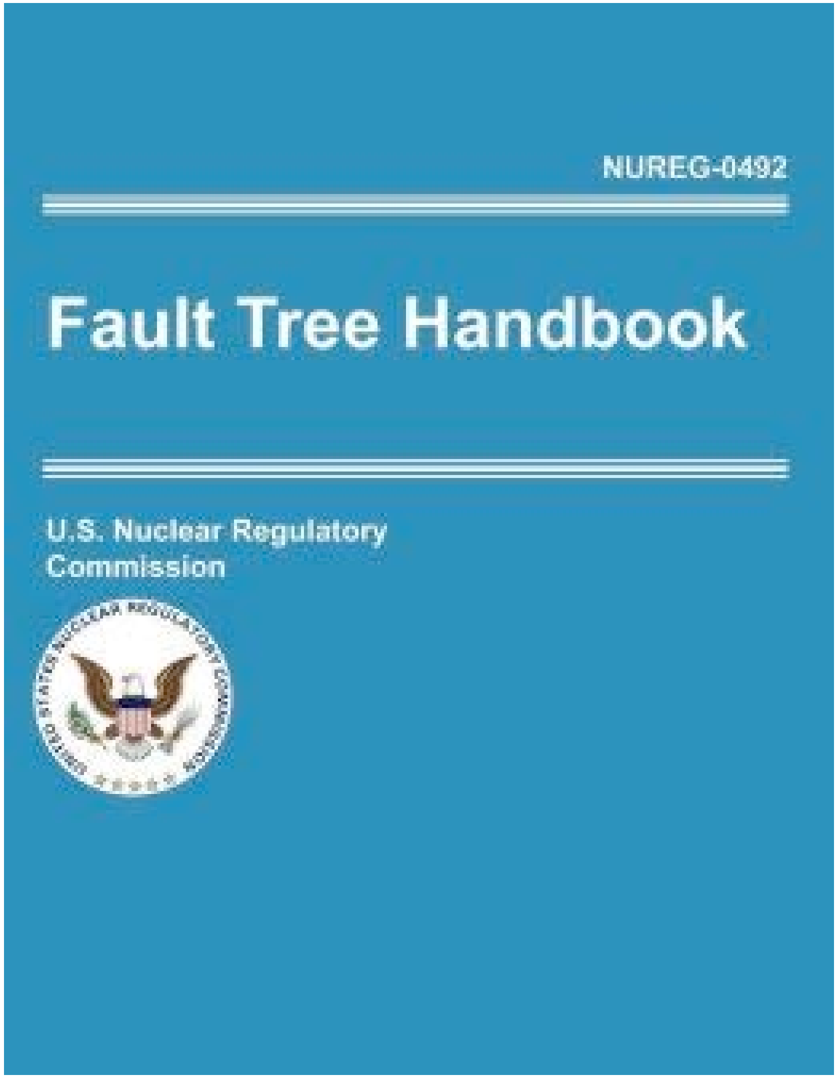
1978

http://www.boeing.com/boeing/commercial/767family/

1979

http://phil.cdc.gov/phil/details.asp?pid=1194

1981



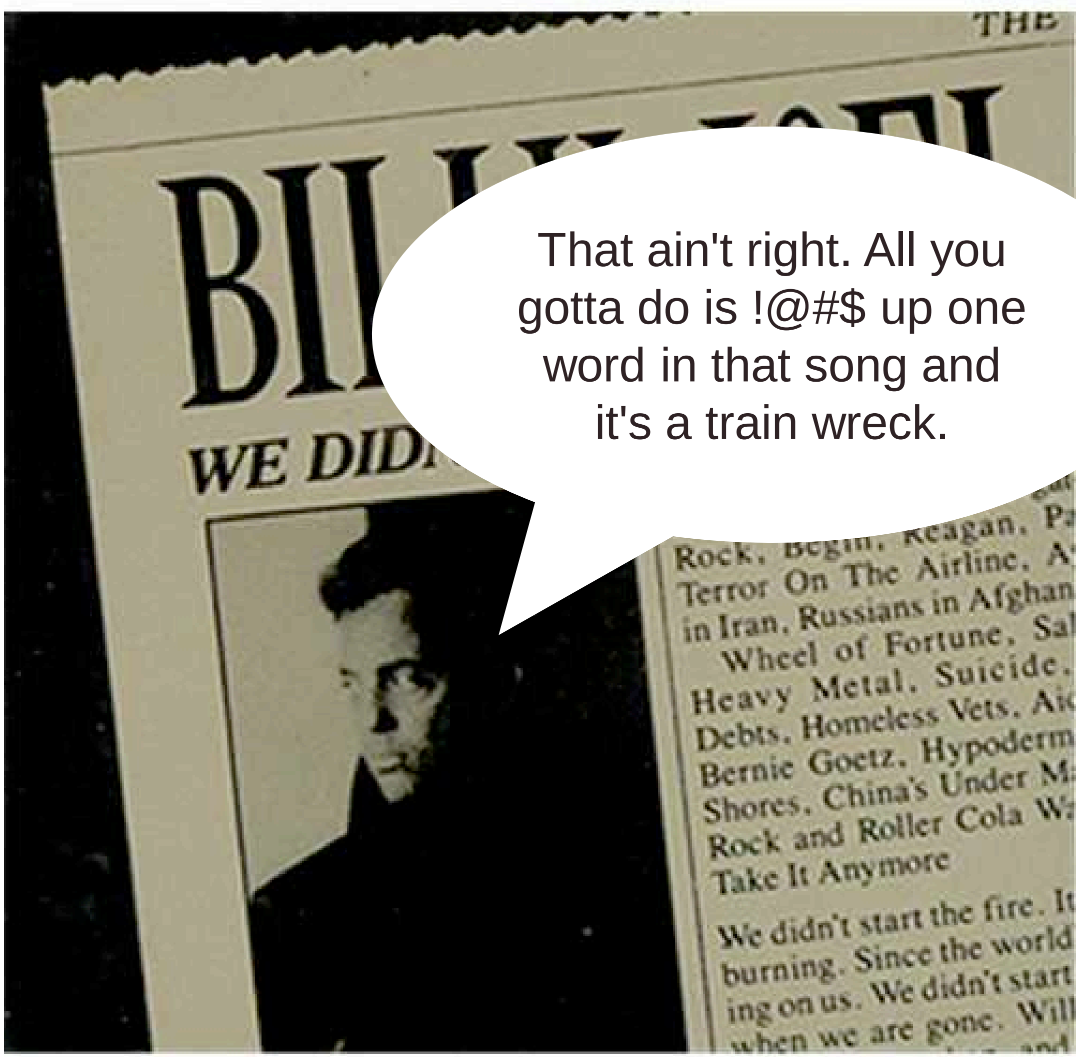
NUREG-0492

Fault Tree Handbook

U.S. Nuclear Regulatory
Commission

http://www.barnesandnoble.com/w/fault-tree-handbook-us-nuclear-regulatory-commission/1113865485

Rock and Roller Cola Wars…



That ain't right. All you gotta do is !@#$ up one word in that song and it's a train wreck.

http://eil.com/shop/moreinfo.asp?catalogid=76681

http://www.rollingstone.com/music/videos/watch-billy-joel-forget-the-lyrics-to-we-didnt-start-the-fire-20140314

https://www.youtube.com/watch?v=waOp_cVluNg

1984

http://www.bhopal.net/what-happened-in-bhopal/

1986

This very complex and costly "fault tree analysis" suggests ways to avoid those sequences [that could cause accidents]…Bill J. McCarty, who oversees safety analysis at NASA…said the fault tree method was not applied to the rocket boosters before the accident and is just now being used to check whether the agency missed any potential causes of failure...He and others in the agency stood behind their methods. "We have done an excellent job in ferreting out the weaknesses," Mr. McCarty said.

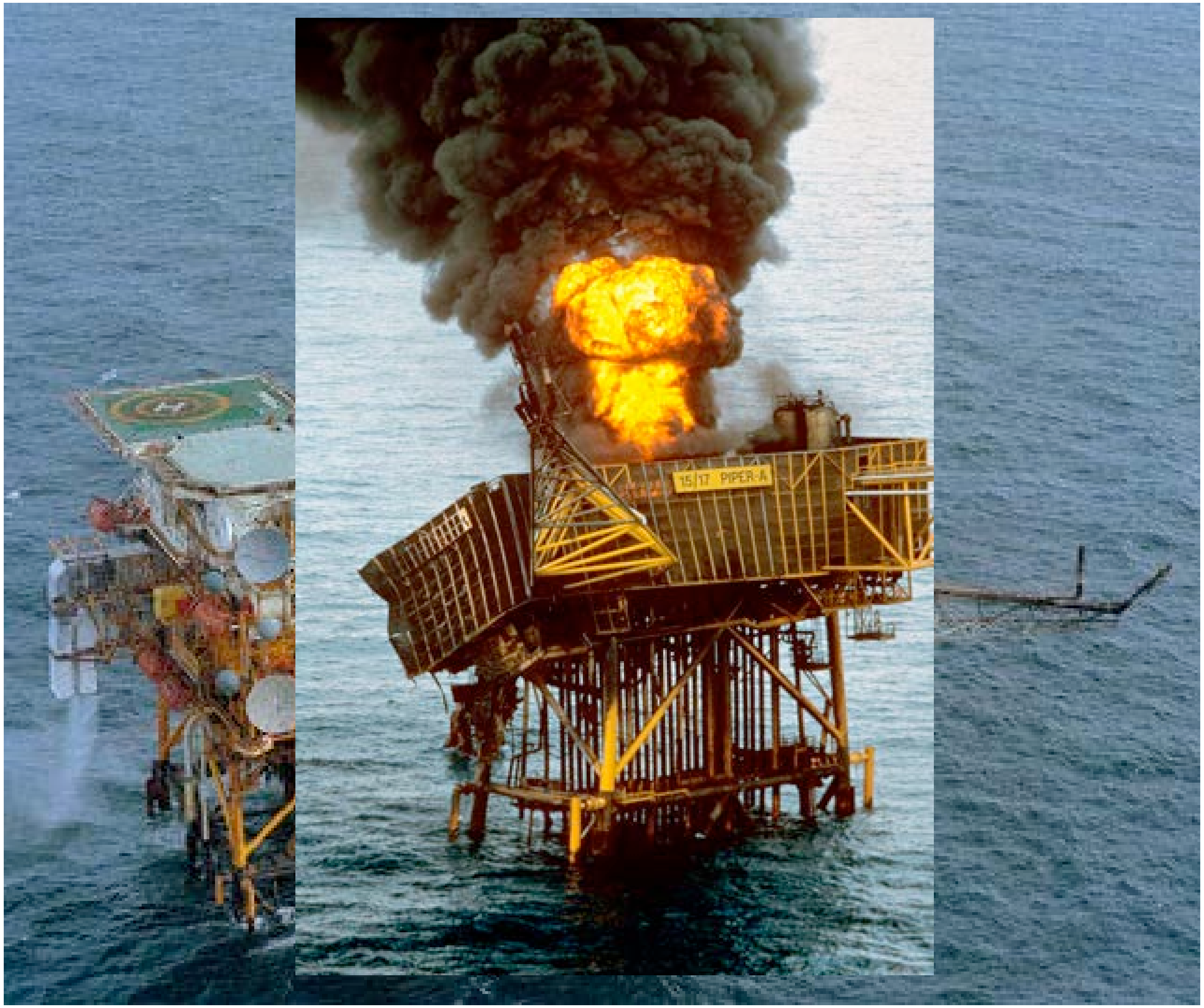
Nevertheless, some of the foremost experts on risk said that NASA's method was more likely to miss critical failure sequences because it…depends on those doing the study to know the system so well that they can make sound judgments in determining which components are most likely to fail.

the fault tree method was not applied to the rocket boosters before the accident and is just now being used to check whether the agency missed any potential causes of failure

http://www.nytimes.com/1986/02/05/us/shuttle-inquiry-exploring-key-wreckage-nasa-s-risk-assessment-isn-t-most.html

http://commons.wikimedia.org/wiki/File:Space_Shuttle_Challenger_(04-04-1983).JPEG

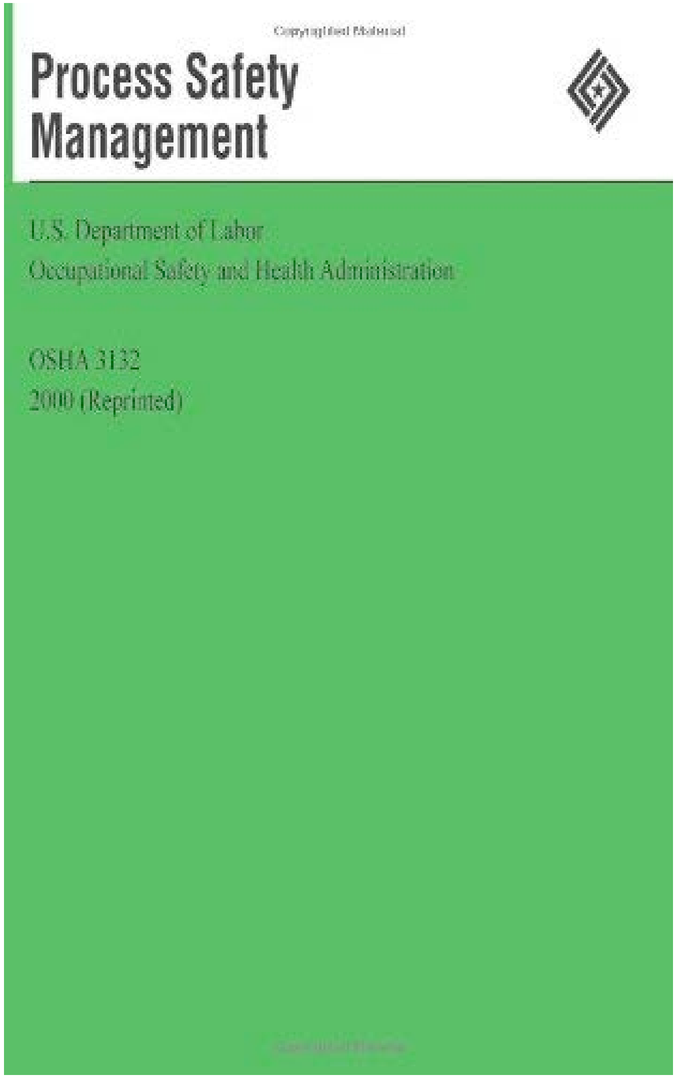
1988



http://firesafetynation.com/images/2%281%29.jpg

http://i.dailymail.co.uk/i/pix/2013/07/06/article-0-1A8FAA3F000005DC-107_634x769.jpg

1992



Copyrighted Material

Process Safety
Management

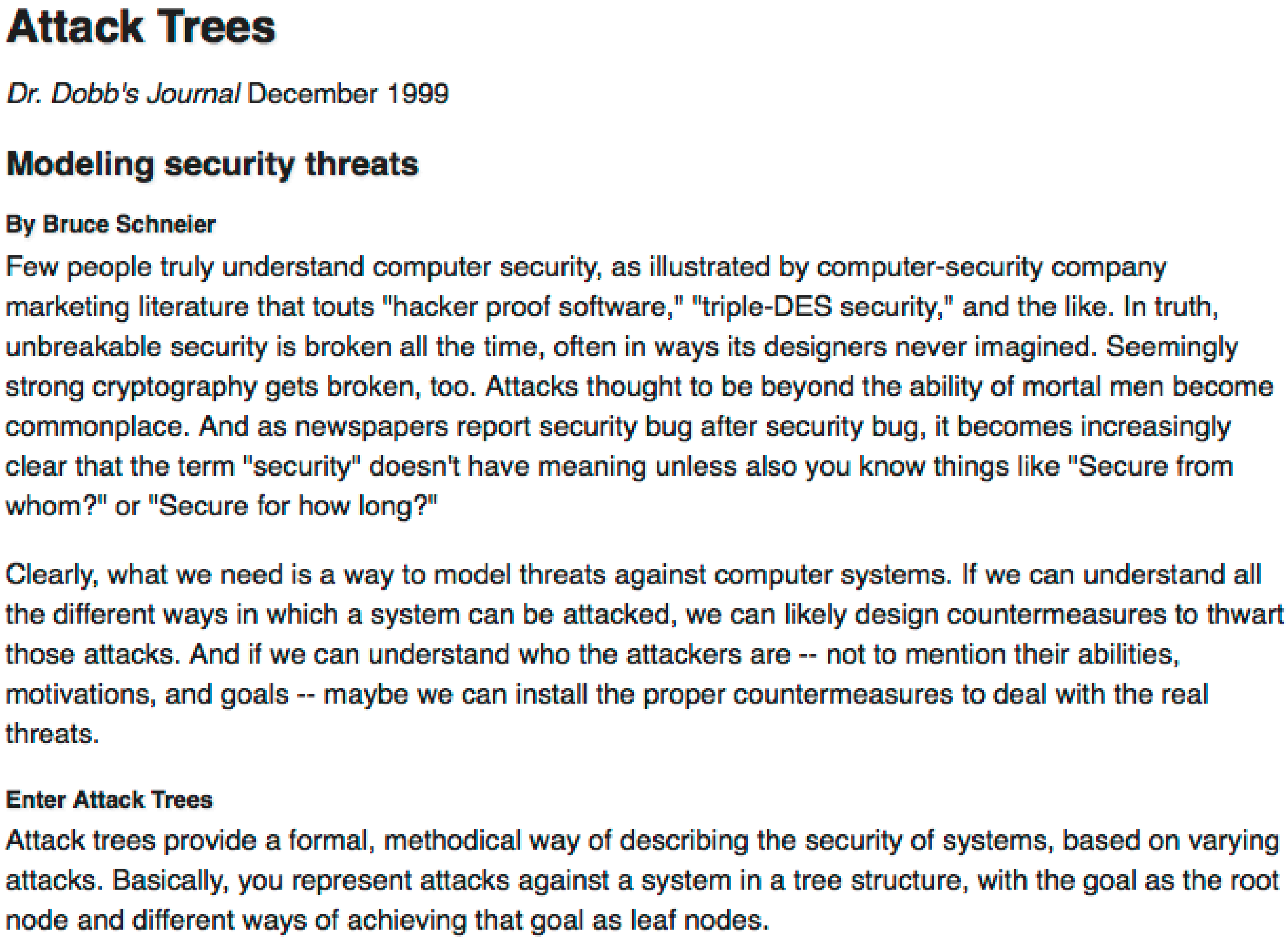
U.S. Department of Labor
Occupational Safety and Health Administration

OSHA 3132
2000 (Reprinted)

Copyrighted Material

http://www.amazon.com/Process-Safety-Management-Department-Labor/dp/1478114207

1999



Attack Trees

Dr. Dobb's Journal December 1999

Modeling security threats

By Bruce Schneier

Few people truly understand computer security, as illustrated by computer-security company marketing literature that touts "hacker proof software," "triple-DES security," and the like. In truth, unbreakable security is broken all the time, often in ways its designers never imagined. Seemingly strong cryptography gets broken, too. Attacks thought to be beyond the ability of mortal men become commonplace. And as newspapers report security bug after security bug, it becomes increasingly clear that the term "security" doesn't have meaning unless also you know things like "Secure from whom?" or "Secure for how long?"

Clearly, what we need is a way to model threats against computer systems. If we can understand all the different ways in which a system can be attacked, we can likely design countermeasures to thwart those attacks. And if we can understand who the attackers are -- not to mention their abilities, motivations, and goals -- maybe we can install the proper countermeasures to deal with the real threats.

Enter Attack Trees

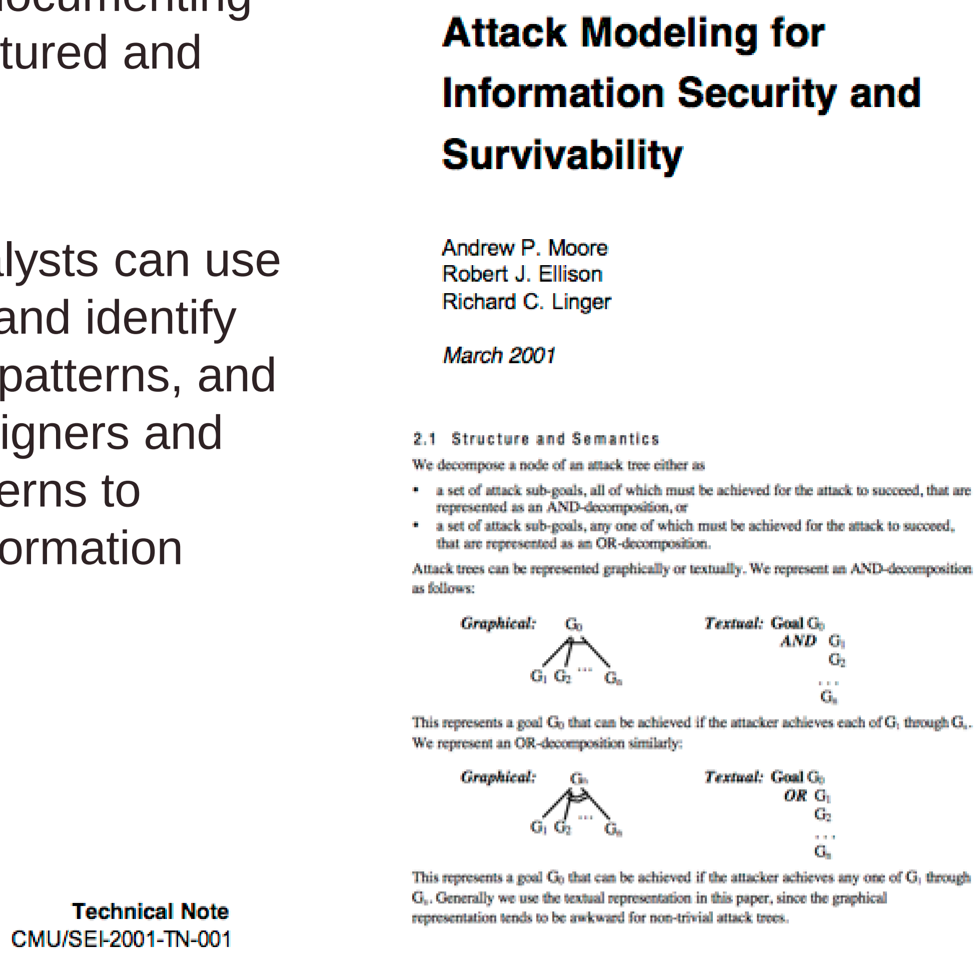
Attack trees provide a formal, methodical way of describing the security of systems, based on varying attacks. Basically, you represent attacks against a system in a tree structure, with the goal as the root node and different ways of achieving that goal as leaf nodes.

https://www.schneier.com/paper-attacktrees-ddj-ft.html

2001

"This technical note describes and illustrates an approach for documenting attack information in a structured and reusable form.

We expect that security analysts can use this approach to document and identify commonly occurring attack patterns, and that information system designers and analysts can use these patterns to develop more survivable information systems."



Attack Modeling for Information Security and Survivability

Andrew P. Moore
Robert J. Ellison
Richard C. Linger

March 2001

Technical Note
CMU/SEI-2001-TN-001

2.1 Structure and Semantics

We decompose a node of an attack tree either as

- a set of attack sub-goals, all of which must be achieved for the attack to succeed, that are represented as an AND-decomposition, or
- a set of attack sub-goals, any one of which must be achieved for the attack to succeed, that are represented as an OR-decomposition.

Attack trees can be represented graphically or textually. We represent an AND-decomposition as follows:

Graphical:

Textual: Goal G_0
AND G_1
G_2
...
G_n

This represents a goal G_0 that can be achieved if the attacker achieves each of G_1 through G_n. We represent an OR-decomposition similarly:

Graphical:

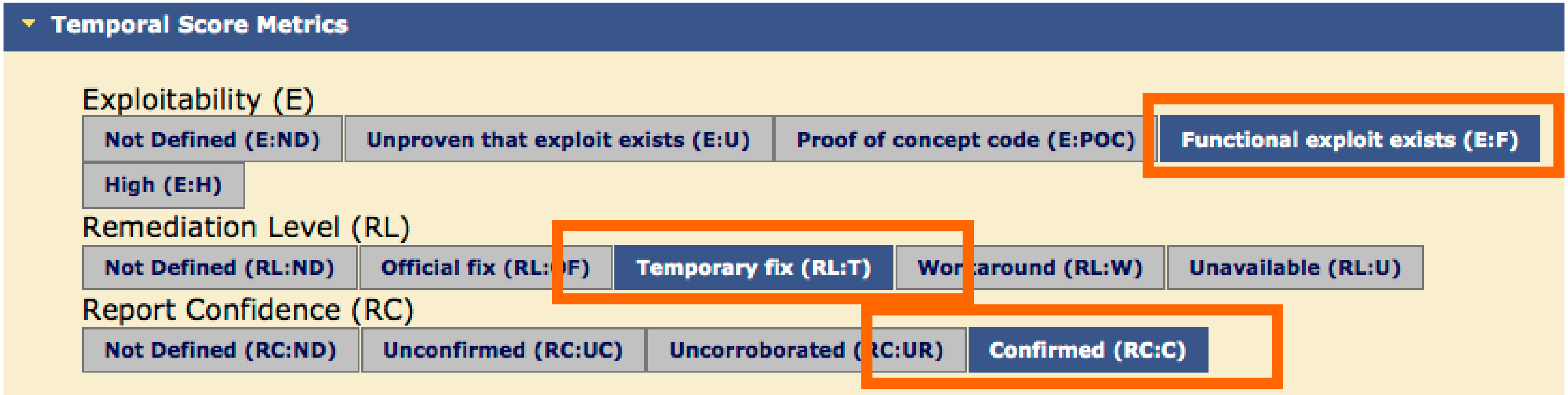
Textual: Goal G_0
OR G_1
G_2
...
G_n

This represents a goal G_0 that can be achieved if the attacker achieves any one of G_1 through G_n. Generally we use the textual representation in this paper, since the graphical representation tends to be awkward for non-trivial attack trees.

2001

http://en.wikipedia.org/wiki/File:World_Trade_Center,_New_York_City_-_aerial_view_%28March_2001%29.jpg

CVSS v2 2001



Temporal Score Metrics

Exploitability (E)

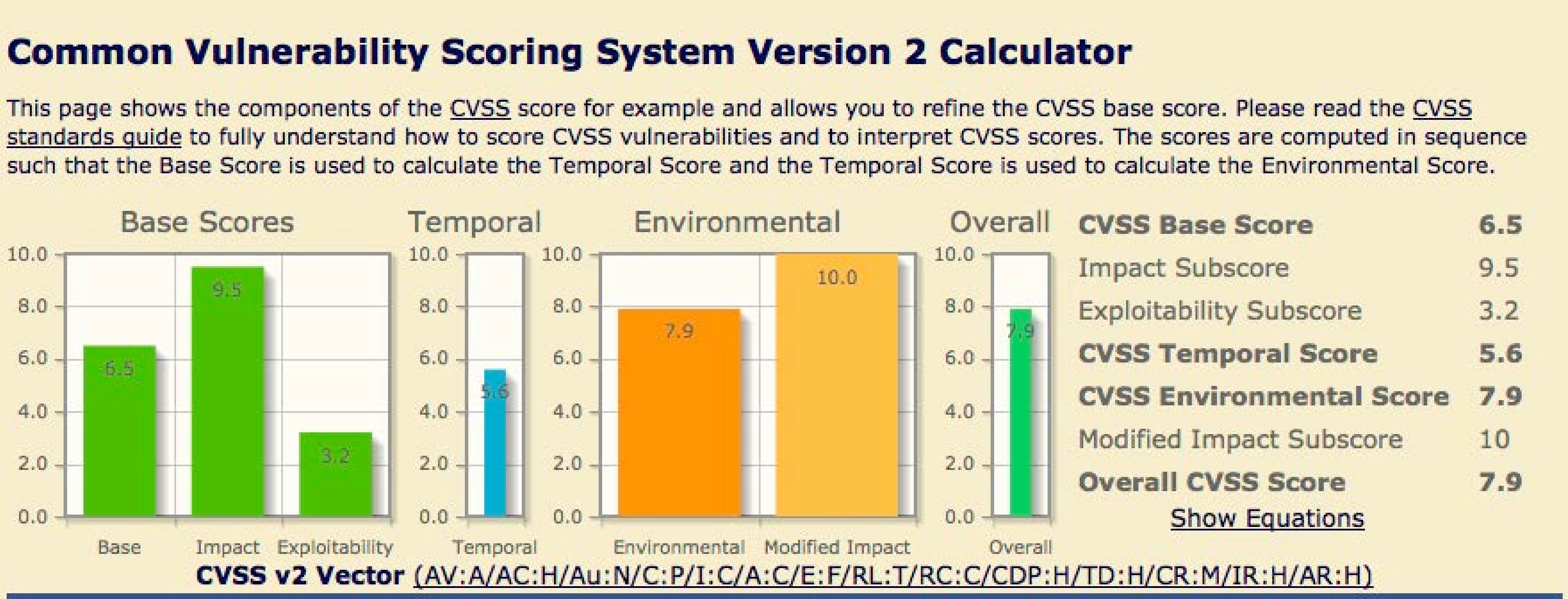
Not Defined (E:ND) | Unproven that exploit exists (E:U) | Proof of concept code (E:POC) | [✓ Functional exploit exists (E:F)] | High (E:H)

Remediation Level (RL)

Not Defined (RL:ND) | Official fix (RL:OF) | [✓ Temporary fix (RL:T)] | Workaround (RL:W) | Unavailable (RL:U)

Report Confidence (RC)

Not Defined (RC:ND) | Unconfirmed (RC:UC) | Uncorroborated (RC:UR) | [✓ Confirmed (RC:C)]



Common Vulnerability Scoring System Version 2 Calculator

This page shows the components of the CVSS score for example and allows you to refine the CVSS base score. Please read the CVSS standards guide to fully understand how to score CVSS vulnerabilities and to interpret CVSS scores. The scores are computed in sequence such that the Base Score is used to calculate the Temporal Score and the Temporal Score is used to calculate the Environmental Score.

CVSS Base Score	**6.5**
Impact Subscore	9.5
Exploitability Subscore	3.2
CVSS Temporal Score	**5.6**
CVSS Environmental Score	**7.9**
Modified Impact Subscore	10
Overall CVSS Score	**7.9**

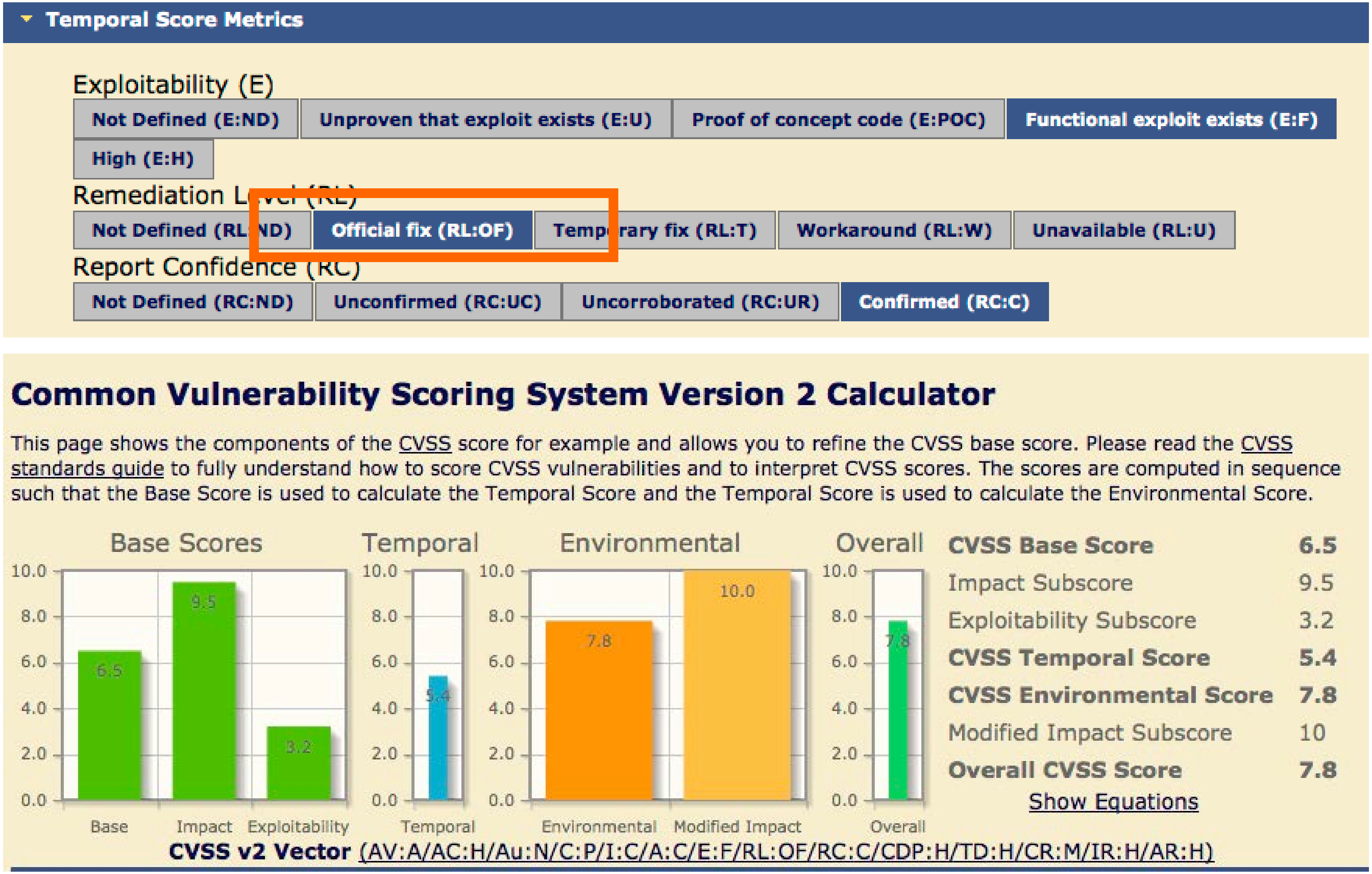
Show Equations

CVSS v2 Vector (AV:A/AC:H/Au:N/C:P/I:C/A:C/E:F/RL:T/RC:C/CDP:H/TD:H/CR:M/IR:H/AR:H)

2002

http://www.afhso.af.mil/shared/media/photodb/photos/110802-D-LN615-001.jpg http://www.afhso.af.mil/topics/factsheets/factsheet.asp?id=18593

CVSS v2 2002



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CVSS v2 Vector (AV:A/AC:H/Au:N/C:P/I:C/A:C/E:F/RL:OF/RC:C/CDP:H/TD:H/CR:M/IR:H/AR:H)

2003

Veterans of the Challenger experience say that it sounds cautious and logical to argue that all potential causes of the disaster should be examined and eliminated, one by one. Ron D. Dittemore, the shuttle program manager, made that argument again today, saying that he would construct a "fault tree," and that the question of whether insulating foam fatally damaged the heat-shedding tiles would be one branch of that tree.

http://www.nytimes.com/2003/02/07/us/loss-shuttle-search-for-answers-learning-lessons-challenger-inquiry.html

…would construct a "fault tree," and that the question of whether insulating foam fatally damaged the heat-shedding tiles would be one branch of that tree.

http://static.ddmcdn.com/gif/shuttle-columbia-launch-660x433-130201-1.jpg

2009: NASA on Fault Tree Analysis

Fault Tree Analysis (FTA) is one of the most important logic and probabilistic techniques used in Probability Risk Assessment (PRA) and system reliability assessment today. PRA and its underlying techniques, including FTA, has become a useful and respected methodology for safety assessment. Because of its logical, systematic and comprehensive approach, PRA and FTA have been repeatedly proven **capable of uncovering design and operational weaknesses that escaped even some of the best** deterministic safety and engineering experts.

http://www.hq.nasa.gov/office/codeq/software/ComplexElectronics/techniques/fault-tree.htm

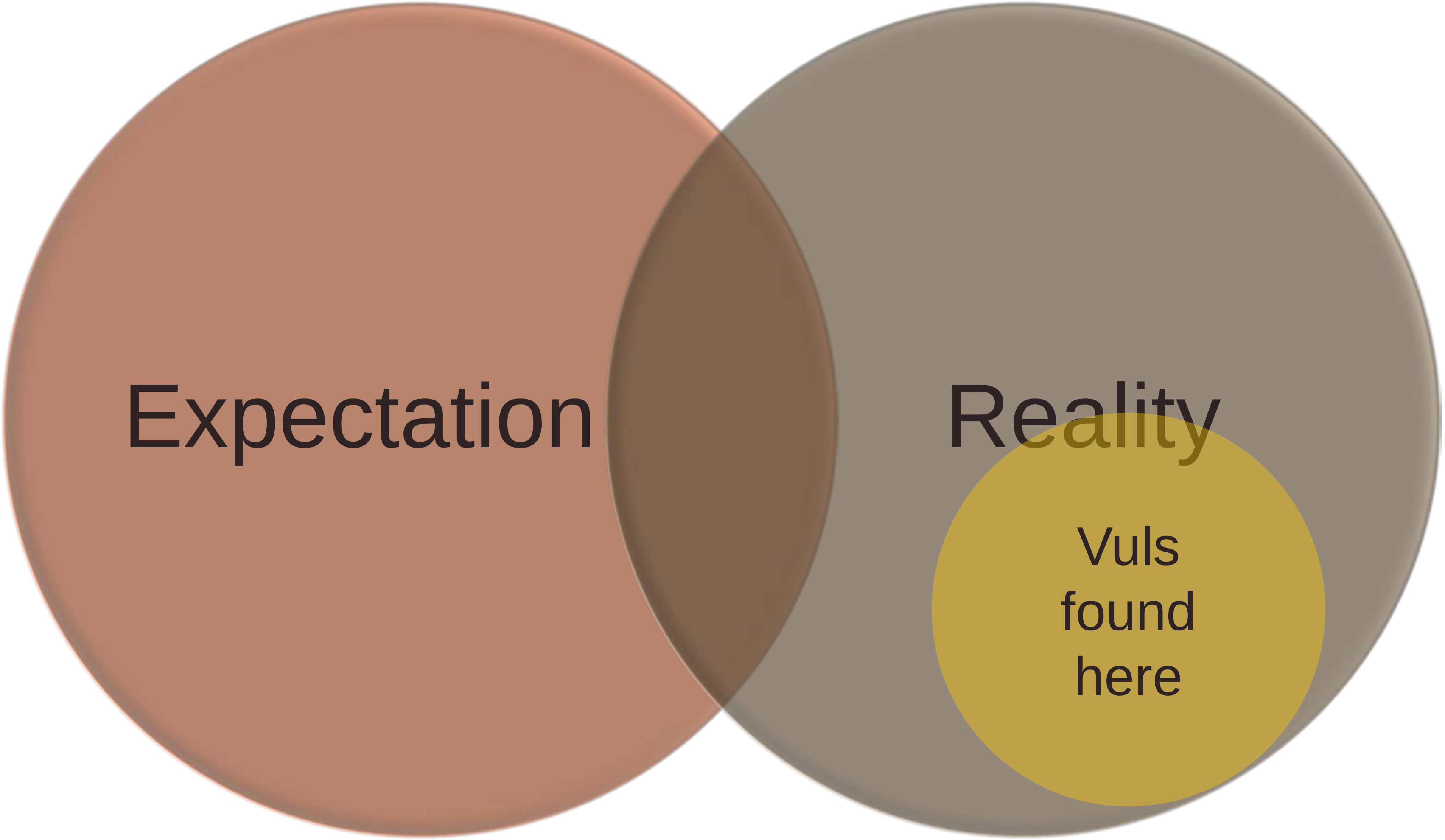
2012: MS Blog on Attack Tree Analysis

“The problem is that attack trees quickly became rather complex. A full attack tree often has hundreds of different paths you can take, making it **difficult to follow visually**. Determining the classification of a threat from attack trees is also far **too labor-intensive**…While the concept of attack trees is sound, the application of this approach is far from it.”

The Evolution of Elevation: Threat Modeling in a Microsoft World

- January 17, 2012, Dana Epp, Microsoft MVP - Enterprise and Developer Security http://technet.microsoft.com/en-us/security/hh778966.aspx

Vulnerability Discovery



Build security in?

At what stage in the process should the Flat Iron Building developers have incorporated defenses against 500+mph airplanes filled with jet fuel?

How harshly should we judge those who declined to defend against threats that science fiction had barely begun to explore when the system was deployed?

Vulnerabilities can arise because the world changes around the system…

…even if the system itself remains unchanged.

2014

The trendline in the count of critical monocultures seems to be rising and most of these are embedded systems both without a remote management interface and long lived. That combination -- **long lived and not reachable** -- is the trend that must be dealt with, possibly even reversed.

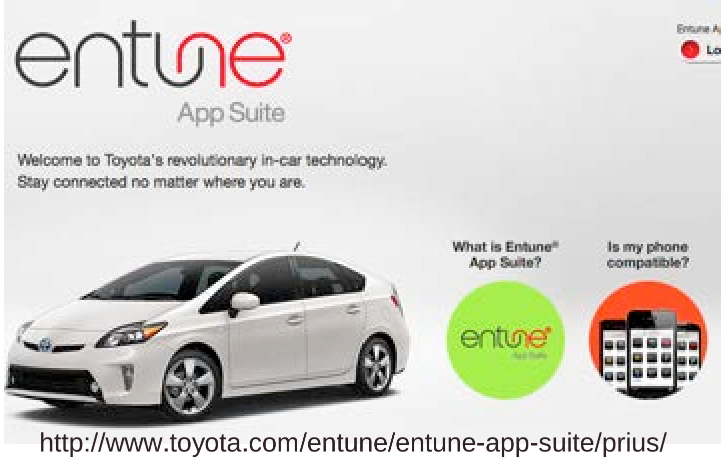
- *Dan Geer, speaking @ NSA on 3/26/14*

http://geer.tinho.net/geer.nsa.26iii14.txt

Points to ponder

How long will your next refrigerator last?

How about your next car?



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App Suite

Welcome to Toyota's revolutionary in-car technology.
Stay connected no matter where you are.

What is Entune® App Suite?

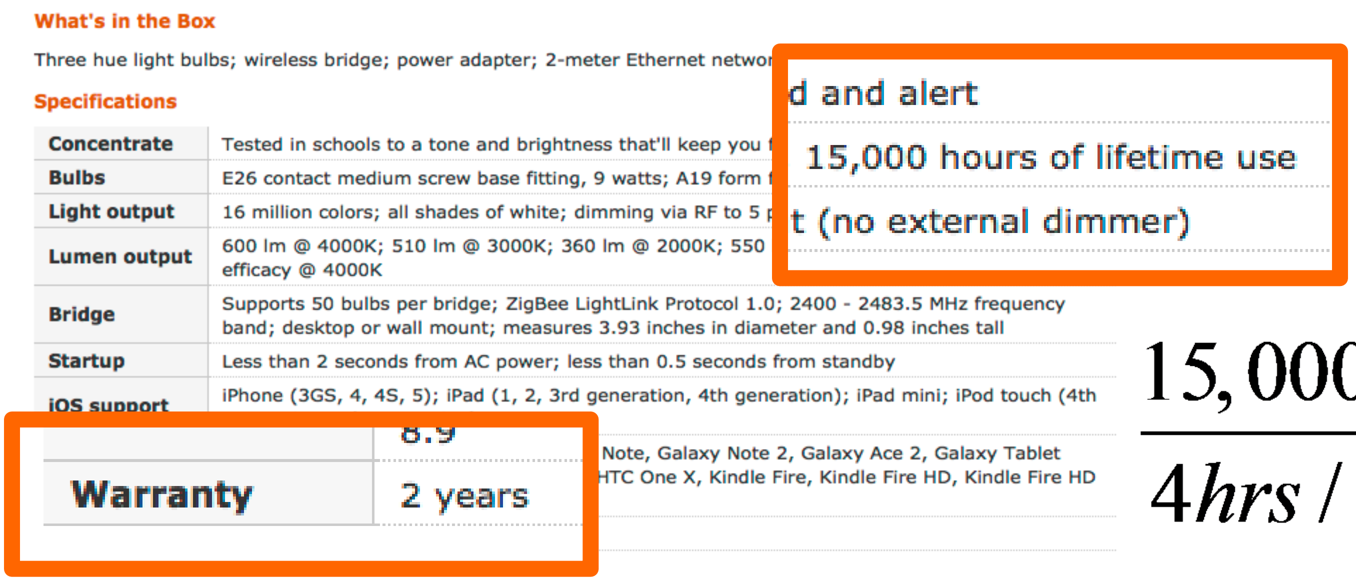
Is my phone compatible?

http://www.toyota.com/entune/entune-app-suite/prius/

http://corporate.ford.com/news-center/press-releases-detail/ford-acquires-software-company-livio-to-further-advance-in-car-c

Points to ponder

How about your light bulbs?



What's in the Box

Three hue light bulbs; wireless bridge; power adapter; 2-meter Ethernet networ

Specifications

Concentrate	Tested in schools to a tone and brightness that'll keep you f
Bulbs	E26 contact medium screw base fitting, 9 watts; A19 form f
Light output	16 million colors; all shades of white; dimming via RF to 5 p
Lumen output	600 lm @ 4000K; 510 lm @ 3000K; 360 lm @ 2000K; 550 efficacy @ 4000K
Bridge	Supports 50 bulbs per bridge; ZigBee LightLink Protocol 1.0; 2400 - 2483.5 MHz frequency band; desktop or wall mount; measures 3.93 inches in diameter and 0.98 inches tall
Startup	Less than 2 seconds from AC power; less than 0.5 seconds from standby
iOS support	iPhone (3GS, 4, 4S, 5); iPad (1, 2, 3rd generation, 4th generation); iPad mini; iPod touch (4th
	8.9 Note, Galaxy Note 2, Galaxy Ace 2, Galaxy Tablet HTC One X, Kindle Fire, Kindle Fire HD, Kindle Fire HD
Warranty	2 years

d and alert

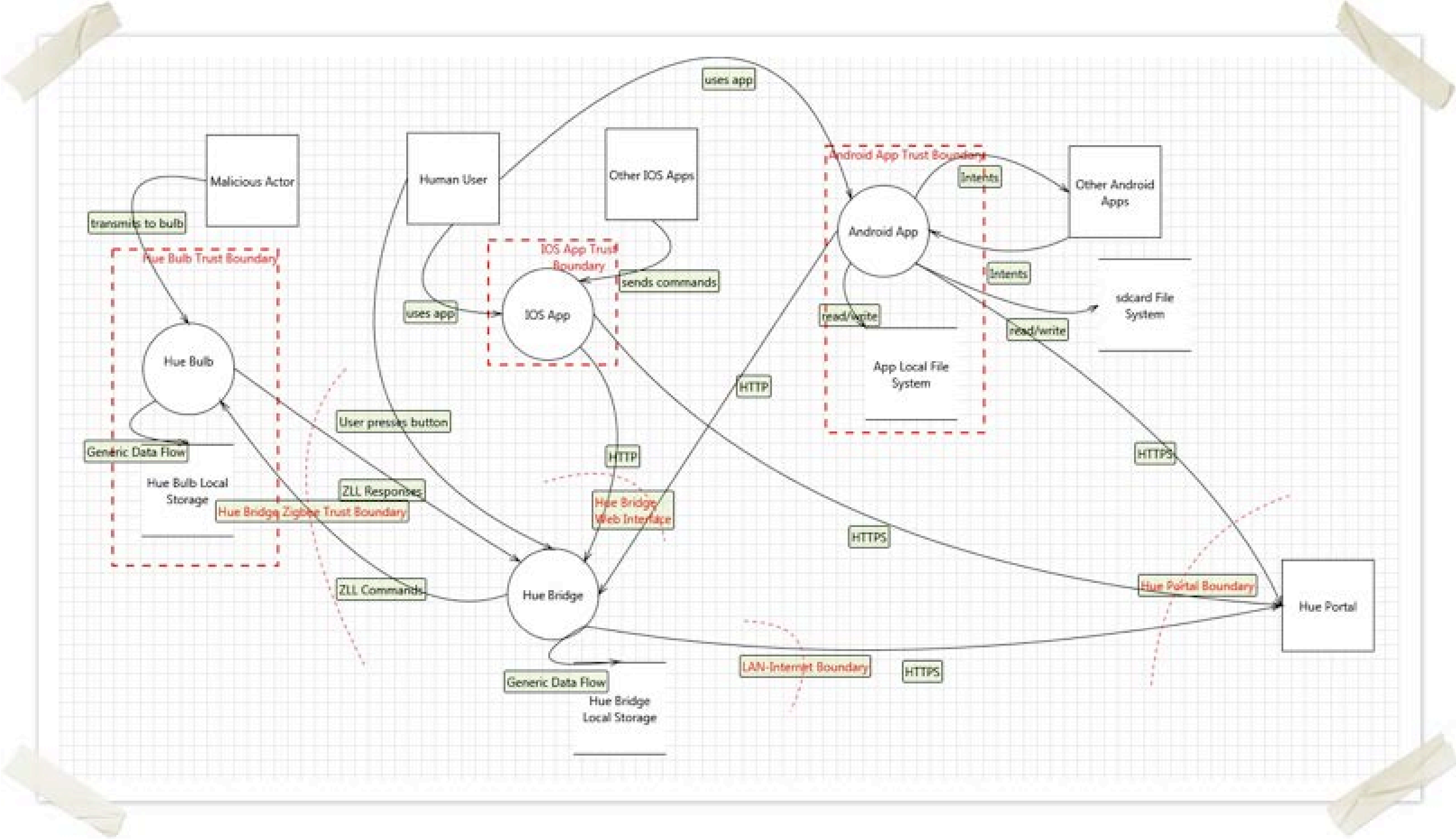
15,000 hours of lifetime use

t (no external dimmer)

$$\frac{15,000hrs}{4hrs/day} \approx 10years$$

Points to ponder

How long will you be able to get patches for them?



Points to ponder

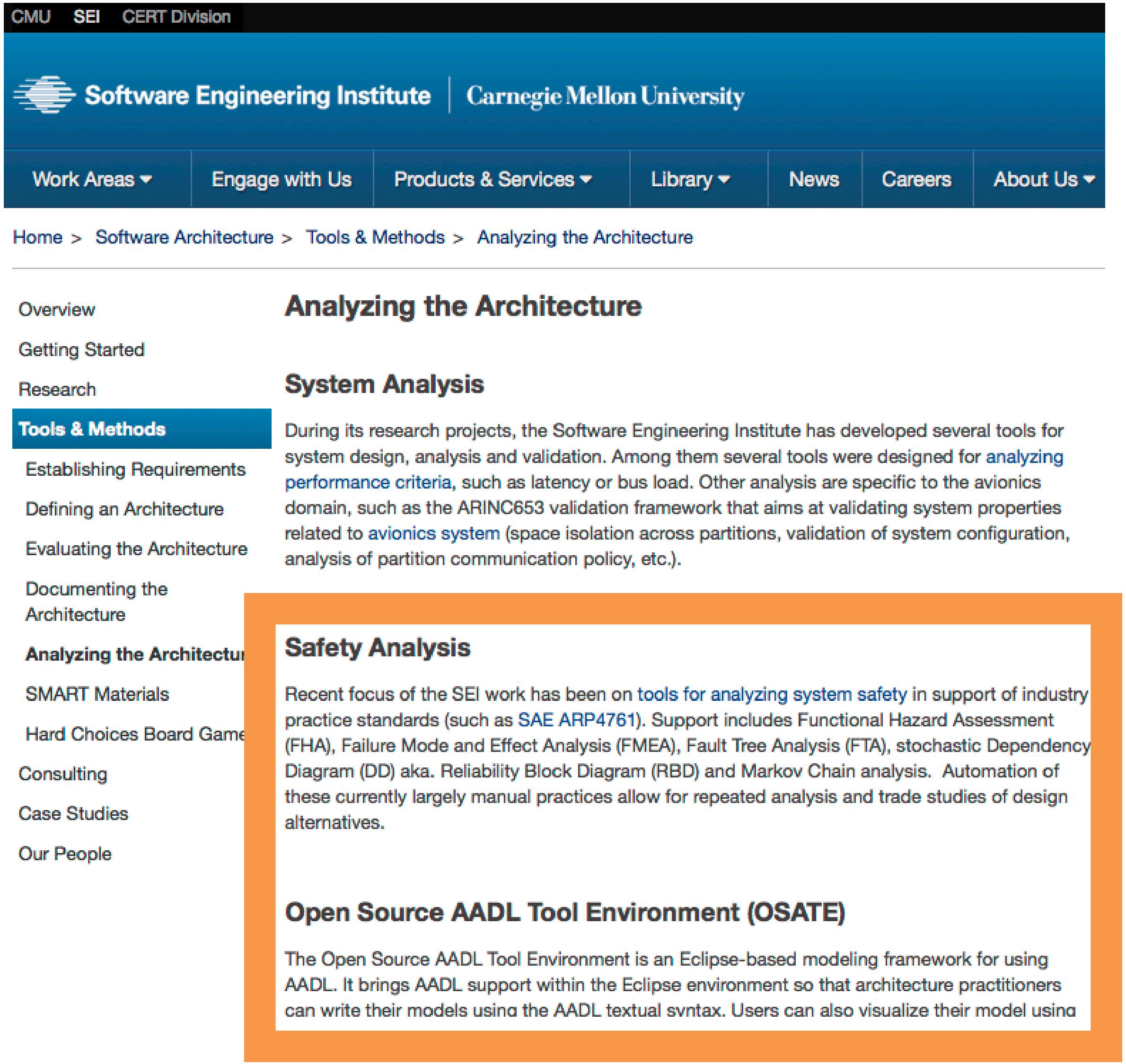
Defense mechanisms

- Field upgradability
- Layered defenses
- Planned obsolescence
- Read more Science Fiction

Design for adaptability to environments that become more hostile over time

Threat modeling and attack tree analysis still have a lot to learn from safety analysis, incl. fault trees

2014


CMU
SEI
CERT Division
Software Engineering Institute | Carnegie Mellon University
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Careers
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Overview
Getting Started
Research
Tools & Methods
Establishing Requirements
Defining an Architecture
Evaluating the Architecture
Documenting the Architecture
Analyzing the Architectur
SMART Materials
Hard Choices Board Game
Consulting
Case Studies
Our People

Analyzing the Architecture

System Analysis

During its research projects, the Software Engineering Institute has developed several tools for system design, analysis and validation. Among them several tools were designed for analyzing performance criteria, such as latency or bus load. Other analysis are specific to the avionics domain, such as the ARINC653 validation framework that aims at validating system properties related to avionics system (space isolation across partitions, validation of system configuration, analysis of partition communication policy, etc.).

Safety Analysis

Recent focus of the SEI work has been on tools for analyzing system safety in support of industry practice standards (such as SAE ARP4761). Support includes Functional Hazard Assessment (FHA), Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), stochastic Dependency Diagram (DD) aka. Reliability Block Diagram (RBD) and Markov Chain analysis. Automation of these currently largely manual practices allow for repeated analysis and trade studies of design alternatives.

Open Source AADL Tool Environment (OSATE)

The Open Source AADL Tool Environment is an Eclipse-based modeling framework for using AADL. It brings AADL support within the Eclipse environment so that architecture practitioners can write their models using the AADL textual syntax. Users can also visualize their model using

Related work at CERT

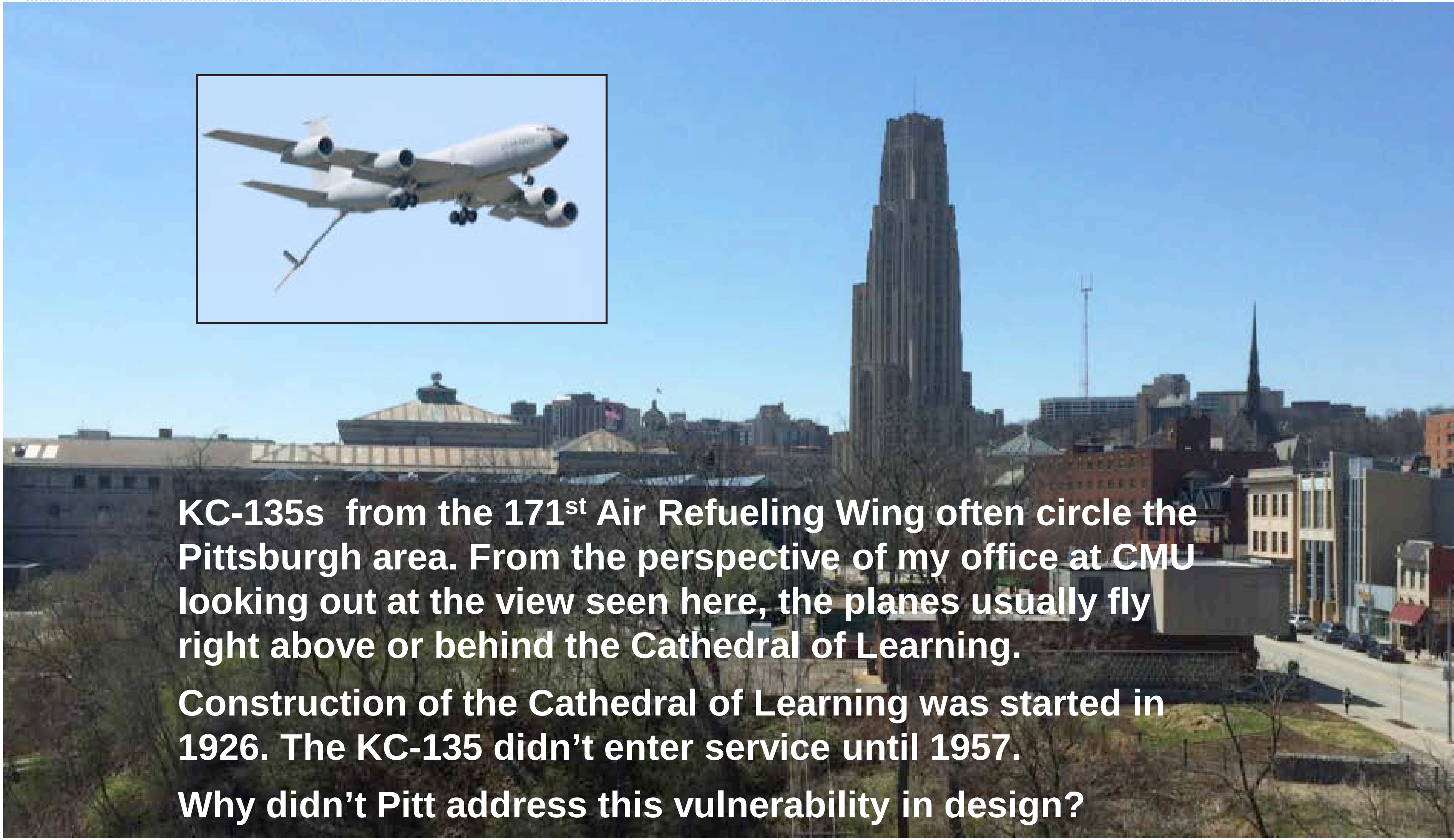
Systemic Vulnerability Program (ongoing)

- Extend focus from vulnerabilities within a single application or program to encompass those that may affect a wide range of applications, networks, and systems.
  - Emerging domain outreach, tool development.
  - Supply chain vulnerabilities (CRDb)

Vulnerability Discovery Research (ongoing)

Extending AADL for Security Design Assurance of the Internet of Things Research (2014-2015)

This talk inspired by…



KC-135s from the 171st Air Refueling Wing often circle the Pittsburgh area. From the perspective of my office at CMU looking out at the view seen here, the planes usually fly right above or behind the Cathedral of Learning.

Construction of the Cathedral of Learning was started in 1926. The KC-135 didn't enter service until 1957.

Why didn't Pitt address this vulnerability in design?

http://www.wingsoverpittsburgh.com/Airshow2010/pics/Kc135FlyingDirty.jpg

"What are you going to make your future of, for all your airs?" And then I suppose I shall return to crane my neck at the Flat-Iron Building or the Times sky scraper, and ask all that too, an identical question.

H.G. Wells, 1906

http://archive.org/stream/hgwellsfuture00wellrich/hgwellsfuture00wellrich_djvu.txt

Google Maps Street View, 2014